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Radio questions and answers

RADIO
QUESTIONS AND ANSWERS

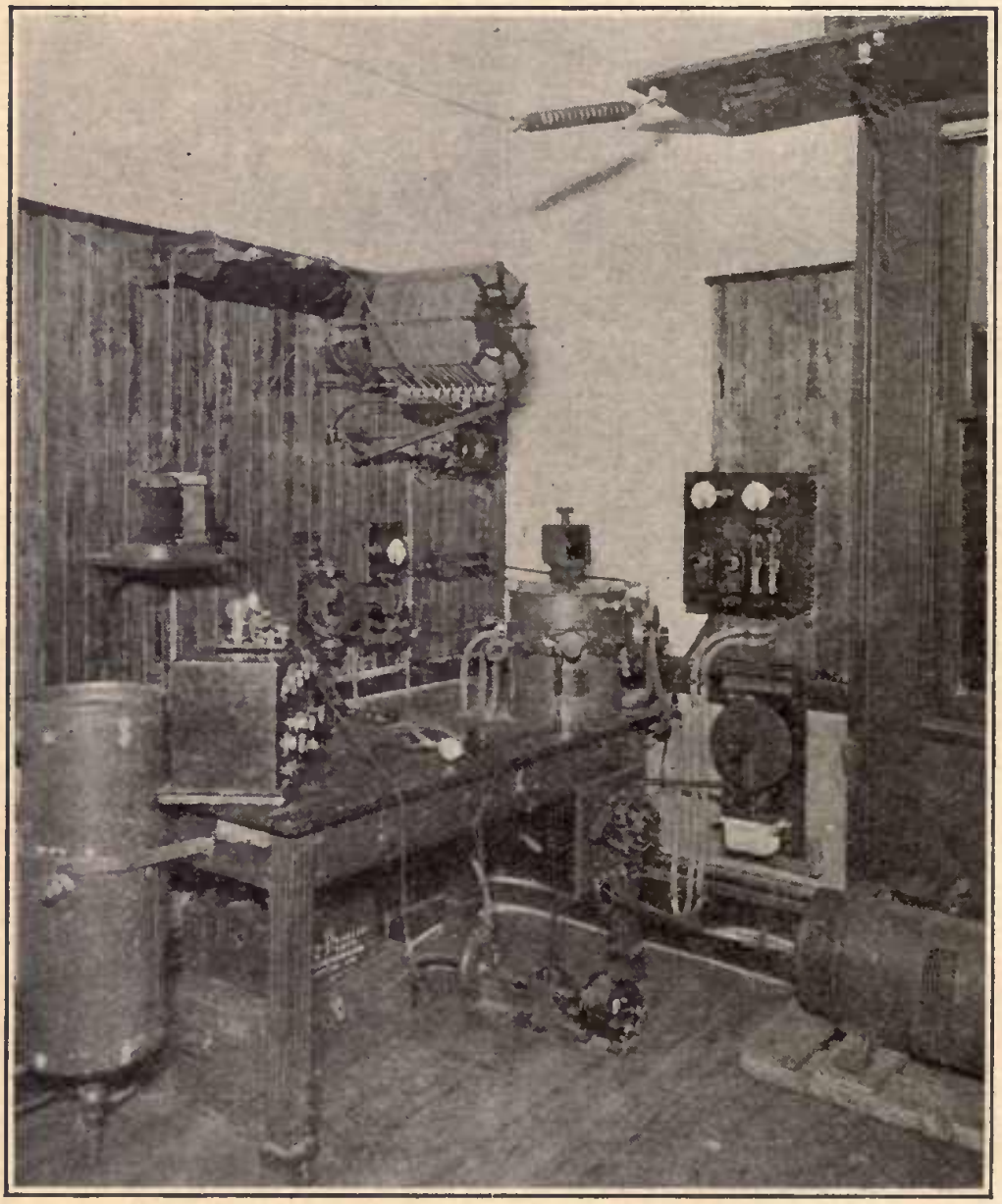

Fig. 1. Modern Arc Ship Installation.

RADIO
QUESTIONS AND ANSWERS

ON GOVERNMENT EXAMINATION FOR RADIO OPERATOR'S LICENSE

BY

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PREFACE

This book is written especially for students and operators who are about to take the government examination for a Radio Operator's License.

The material contained herein has been drawn from many sources, carefully chosen and compiled from the commercial radio operator's standpoint. While the reader may not be willing to accept the text as sufficient in all points, it must be remembered that there are many ways of answering questions and as all viewpoints cannot be taken in a work of this kind, the one considered most expedient was chosen. It is assumed that the reader understands radio operating and theory completely and that this book will merely serve to bring out certain salient points as well as to show the general form of answering questions of this kind.

In conclusion let me caution all applicants who take the Radio Operator's License Examination to answer all questions fully, never using etcetra to explain a meaning. **Do not be brief.**

A. R. N.

CONTENTS

RADIO QUESTIONS AND ANSWERS

Part I

RADIO AND ELECTRICAL THEORY AND PRACTICE

Ques. 1. What effect has the transmission of energy by a power transformer on the impressed frequency?

Ans. None.

Ques. 2. Describe the following properties:—Electromotive force, current, resistance, watts as relating to the D. C. circuit.

Ans. **Electromotive Force**, abbreviated E.M.F., is the term applied to electric pressure and is measured in volts.

Current is defined as the amount of electricity passing a given point in unit time and is measured in amperes.

Resistance is the opposition to the flow of current shown by every D.C. circuit. It is measured in ohms.

Watts are the units by which power is measured. In D.C. circuits the voltage multiplied by the amperes flowing in the circuit gives watts. When figuring the watts consumed in an A.C. circuit the process is, volts $\times$ amperes $\times$ power factor.

Ques. 3. What is meant by spark frequency, generator frequency, wave train frequency?

Ans. By **Spark Frequency** is meant the number of sparks jumping the spark gap per second. It is dependent upon the generator frequency. In modern transmitters properly adjusted, there is one spark per alternation of the A.C. supply. For example, if the generator delivers 500 cycles per second, the spark frequency is 1000 per second or in other words a spark discharges across the spark gap 1000 times per second.

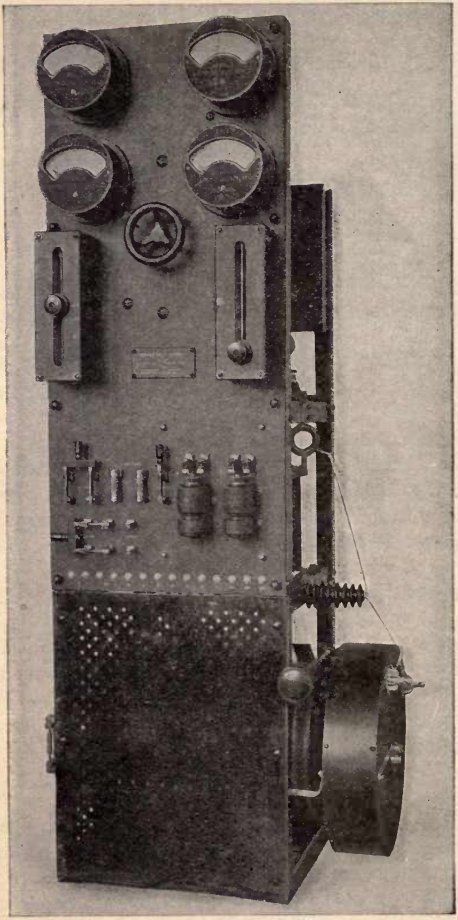


Fig. 2. Independent Spark Transmitter
(Courtesy, Independent Wireless Telegraph Co.)

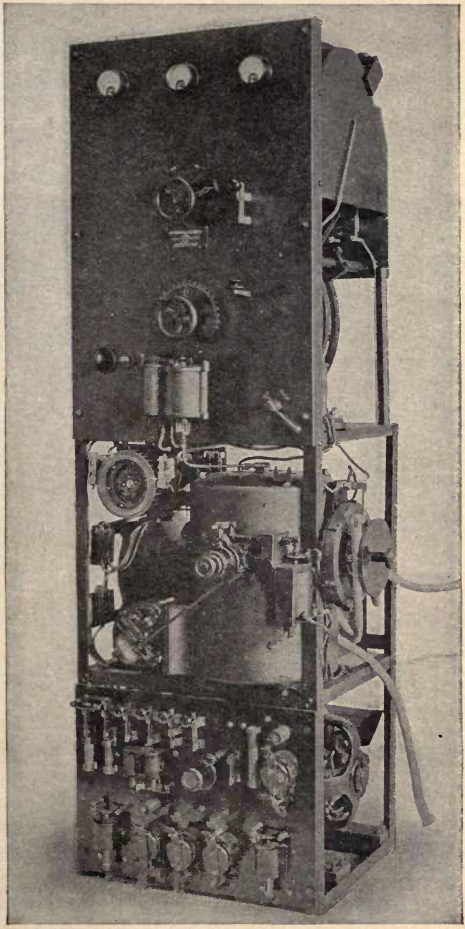


Fig. 3. Independent Arc Transmitter
(Courtesy, Independent Wireless Telegraph Co.)

Generator Frequency is the number of cycles per second of the electromotive force delivered by the alternator. The frequency is expressed in cycles per second.

Wave Train Frequency denotes the number of wave trains or groups of wave trains radiated per second by the open radiating or antenna circuit of a radio transmitter.

Ques. 4. Define induction, self induction.

Ans. **Induction** is the act or process by which an electrical conductor or a magnetizable body becomes itself electrified or magnetized in the presence, without necessarily actual contact, of an electrically charged body, a magnet, or a magnetic field produced by an electric current.

Changes in the magnetic field surrounding a conductor will induce E.M.F. in the circuit itself. This is called **self induction**, provided the winding in question produces the field.

Ques. 5. Has an undamped wave a decrement?

Ans. It has zero decrement.

Ques. 6. Four condensers of .002 microfarads are connected in series. What is the total capacitance?

Ans. The formula for condensers in series is

$$\frac{1}{C}=\frac{1}{C_1}+\frac{1}{C_2}+\frac{1}{C_3}+\frac{1}{C_4}$$

which applied to the above example reads:

$\frac{1}{C}=\frac{1}{.002}+\frac{1}{.002}+\frac{1}{.002}+\frac{1}{.002}=\frac{4}{.002}=2000$, therefore $C=\frac{1}{2000}=.0005$ microfarads.

When all capacitance values are alike as in the above example the total capacitance when series connection is used is the capacitance of one condenser divided by the number in the bank.

Ques. 7. What is meant by a broadly tuned circuit?

Ans. A broadly tuned circuit is one that responds (receiver) or transmits (transmitter) over a wide range of wave-

lengths. One in which the logarithmic decrement exceeds two-tenths.

Ques. 8. What is a sharp wave?

Ans. A sharp wave is one in which the logarithmic decrement per complete oscillation does not exceed two-tenths.

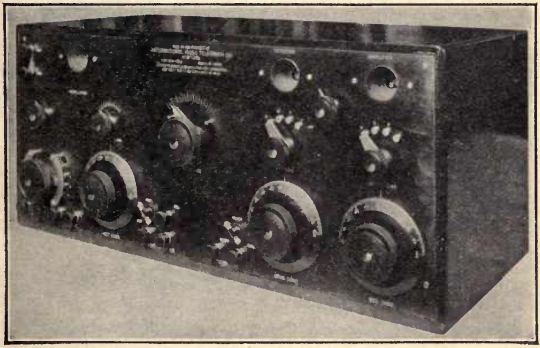


Fig. 4. International Receiver
(Courtesy, International Radio Telegraph Co.)

Ques. 9. What is a pure wave?

Ans. A pure wave is the radiated wave of a transmitter, the character of which is such that it radiates two or more wavelengths, the shorter wave not radiating more than 10 per cent of the energy radiated by the desired longer wave.

Ques. 10. What is capacitance?

Ans. That property possessed by a condenser which enables it to hold a charge of electricity is called capacitance (capacity).

Ques. 11. What is the effect of placing a condenser in series with the antenna, and under what conditions is it necessary?

Ans. Placing a condenser in series with the antenna decreases the resulting capacitance and consequently the wavelength. When the natural wavelength of the antenna is higher than that which is desired the wavelength of the circuit may be reduced by connecting a condenser in series. The wavelength may be reduced nearly to one-half by this method but not below such a value for reasonable efficiency. Any decrease below the natural wavelength tends to decrease efficiency.

Part II

TRANSMITTING APPARATUS, SPARK

Ques. 12. How do you increase radiation with a synchronous rotary spark transmitter?

Ans. If the primary E.M.F. to the step up power transformer is fixed the radiation in the open oscillating circuit of a transmitter equipped with a synchronous rotary spark gap may be increased by carefully manipulating the angular adjustment of the stationary electrodes and varying the coupling between the open and closed oscillating circuits. A variation of the speed of the motor generator will also effect the radiation, causing it to increase or decrease depending upon various conditions in the apparatus. When adjusting for increased radiation the antenna ammeter should be carefully watched. Increasing the input to the power transformer will usually result in increased radiation on any type of transmitter.

Ques. 13. How may the radiation of a quenched gap transmitter be increased?

Ans. Generally speaking, the radiation of a quenched gap transmitter may be increased by increasing the number of gap units in use and carefully varying the coupling between the open and closed oscillating circuits. It is, of course, possible to use too many units of the quenched gap at once, thereby endangering the insulation of the set as a whole. The correct number for maximum radiation with a particular set may best be found by experiment. Increasing the input to the primary of the power transformer will increase the radia-

tion but care must be taken not to overload the set by using too high power.

Ques. 14. What is meant by ratio of transformation of the step up transformer?

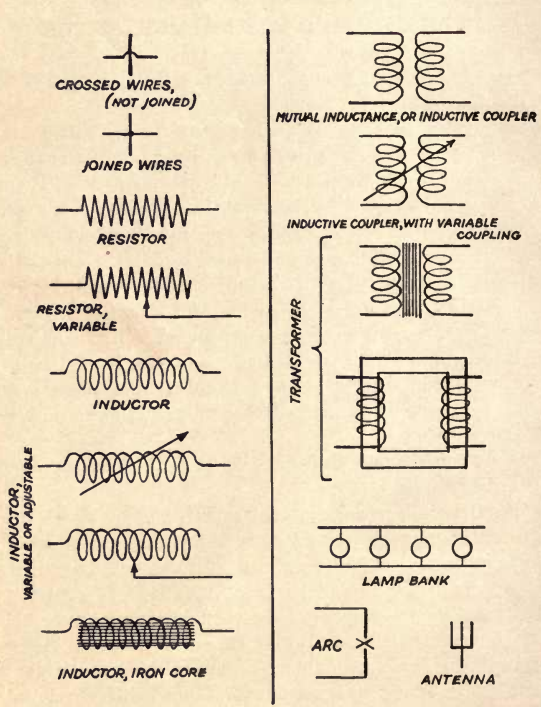


Fig. 5. Standard Symbols I

Ans. By ratio of transformation we compare the primary input volts with secondary output volts. The ratio of trans-

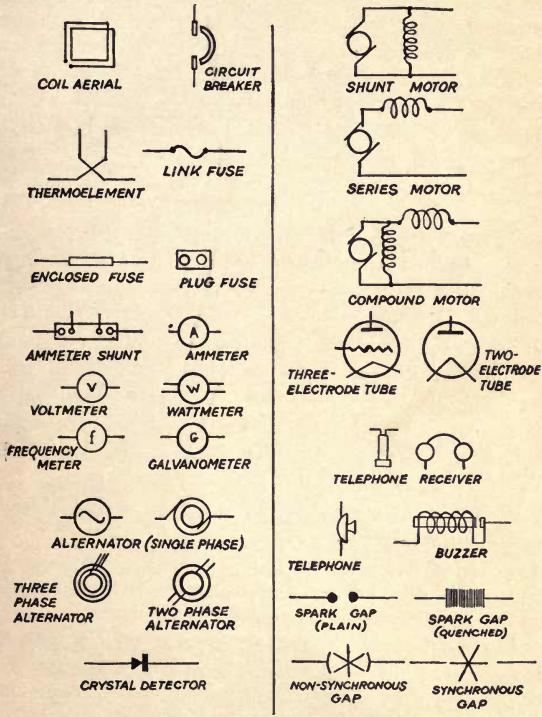


Fig. 6. Standard Symbols II

formation is the ratio of the number of turns of wire on the secondary to the number of turns on the primary. If, for

instance, a transformer steps up the voltage from 100 volts to 5000 volts the ratio of transformation would be 50, or in other words, the voltage is stepped up fifty times. Now let us assume that the primary of the transformer has 400 turns. In order to step up the impressed voltage fifty times it would be necessary to have fifty times as many turns on the secondary as are on the primary, or 20,000 turns.

Ques. 15. Of what use is a hot wire ammeter in a transmitting circuit?

Ans. A hot wire ammeter is used to indicate resonance between the open and closed oscillating circuits and also indicates in a relative way the energy radiated by the transmitting set. In modern apparatus the hot wire ammeter is replaced by a thermo-couple electro-magnetic ammeter which is called the antenna ammeter or radio frequency ammeter.

Ques. 16. Of what use is an antenna tuning inductance in connection with a radio transmitter?

Ans. The antenna tuning inductance or loading coil as it is more generally termed is used in the open oscillating circuit of a radio transmitter for obtaining wavelengths beyond the range of the oscillation transformer alone.

Ques. 17. What effect has the closed circuit of a transmitter upon the frequency?

Ans. The closed oscillatory circuit greatly increases the frequency of the high voltage alternating current supplied from the secondary of the step up transformer. This is necessary in order to produce ether waves to travel over long distances. In any spark transmitter the closed circuit may, for example, increase the frequency as high as 600,000 or more cycles per second.

Ques. 18. Where are the protective condensers usually located in transmitting apparatus? Explain fully, giving their purpose.

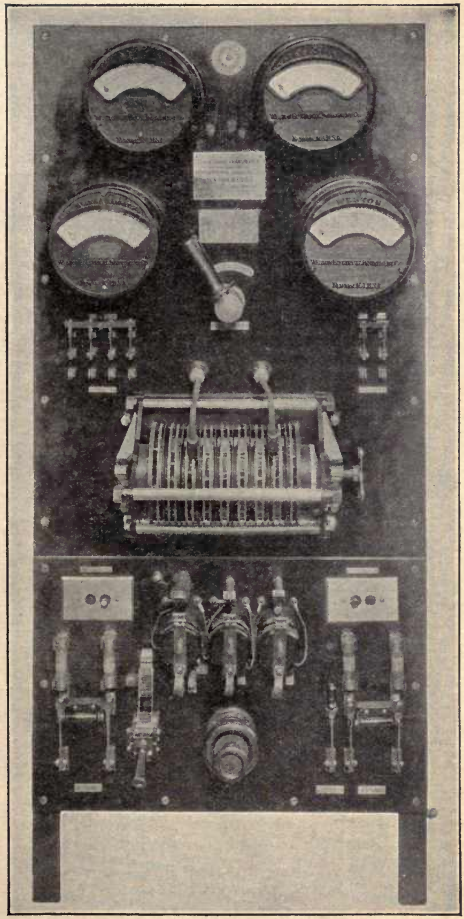


Fig. 7. International Panel
(Courtesy, International Radio Telegraph Co.)

Ans. Protective condensers are installed as indicated in the diagram figure 43:

(1) Across terminals of primary of power transformer.
(2) Across terminals of armature of alternator.
(3) Across terminals of field of alternator.
(4) Terminals of shunt field of motor.

Protective devices are also placed across the terminals of the armature of blower motor on a quenched gap set. The pur-

Fig. 8. Dubilier Protective Condenser

pose of the protective device is to protect the apparatus to which they are connected from puncture of insulation, should a high voltage kickback occur from the high frequency circuits. A photograph of one of the latest type protective condensers is shown in figure 8.

Ques. 19. Describe fully how you would proceed to adjust a spark transmitter to a given wavelength.

Ans. It is well to remember in answering a question of this kind that a spark transmitter of the types commonly used

today have two independent circuits, namely; the closed oscillating circuit consisting of the condensers (capacitance), the primary turns of the oscillation transformer (inductance) and the spark gap; and the open oscillating circuit consisting of the secondary of the oscillation transformer, antenna tuning inductance (loading coil) radio frequency ammeter, antenna and ground. A variation of the capacitance or inductance value in either of these circuits affects the radiated wave. First, tune the closed circuit to the desired wavelength by closing the key and causing the spark to jump the gap. Situate the wavemeter in inductive relation to the circuit and take a reading. Resonance on the wavemeter will be indicated, according to the type of wavemeter used, by a maximum sound in the telephone, a maximum reading of a current reading meter or the brightness of a glow lamp. Whichever device is used resonance will be indicated by a maximum indication.

If the wavelength reads high reduce the number of turns of inductance, if too low increase the inductance by adding turns. It is not necessary to adjust the capacitance (condensers) as this is fixed at the factory. However, for three hundred meters a switching or plugging arrangement cuts down the value of the capacitance automatically and this switch or plug must be in the proper position.

While it is not absolutely necessary, it is always best when calibrating the closed circuit that all of the various pieces of apparatus comprising the open circuit be disconnected one from the other and the secondary drawn away from the primary coil to the position of minimum coupling. This is so that minimum mutual induction will take place between the circuits thereby eliminating any broadening effect of the measured wave.

When the closed circuit has been tuned to the given wavelength the open circuit is reconnected and the coils of the

oscillation transformer (coupler) brought in close relation. Inductance is then added or subtracted from the secondary or antenna inductance (open circuit) until the antenna ammeter indicates resonance by a maximum indication. This shows that the open circuit is now tuned to the same wavelength as the closed circuit and the set ready for operation.

However, in order that the purity and sharpness of the wave may be checked up the radiated wave should be measured while the transmitter is in actual operation. If two or more waves are present the coupling and inductance values of the secondary and antenna loading coil should be so proportioned that the energy in any of the lesser waves shall not exceed ten per cent of the energy in the desired wave.

A decrement reading should then be taken. According to the law the decrement must not exceed two-tenths for ordinary operation. In view of the fact that it is not necessary to measure for decrement to tune a set to a desired wavelength, an explanation of this operation is omitted in this answer.

Ques. 20. Describe an oscillation transformer. What immediate advantage is obtained from employing such a device?

Ans. An oscillation transformer is shown in figure 9 and may consist of two spirally wound coils one of which is the primary and the other the secondary. The primary consists of from seven to fifteen turns of heavy copper conductor and the secondary coil consists of from five to eight turns of conductor having the same large surface area as that of the primary coil.

An oscillation transformer is useful because it allows a very flexible degree of coupling between the open and closed oscillating circuits with no direct conduction of energy from one circuit to the other. This makes it possible to adjust for a wave of low decrement as well as for a pure wave. When using an oscillation transformer the resistance of the spark

gap is not in the antenna circuit. This, of course, also tends to keep down the decrement of the radiated wave. It is sometimes the practice to decrease the coupling of the oscillation transformer when it is desired to decrease power transmitted

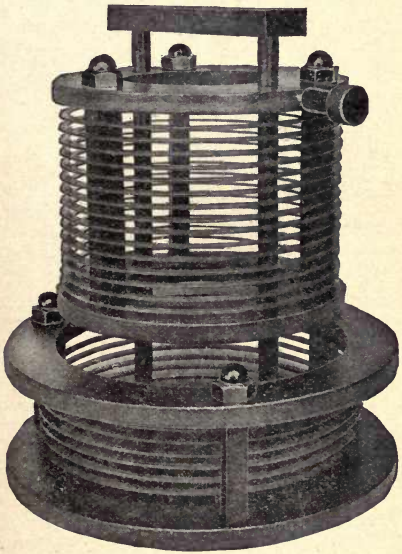


Fig. 9. Oscillation Transformer
(Courtesy, International Radio Telegraph Co.)

but with the newer types of apparatus this method is obsolete.

Ques. 21. What are the principle losses in a power transformer?

Ans. One of the losses that takes place in a power transformer is the heat loss which is the result of eddy currents

and the effect known as hysterisis in the iron core. To lessen this loss, transformer cores are built up of laminated soft iron strips each strip having a coat of insulating shellac or japan applied before assembly into the final form. There is also a loss in the windings called the copper loss.

Ques. 22. Describe some form of impact excitation transmitter.

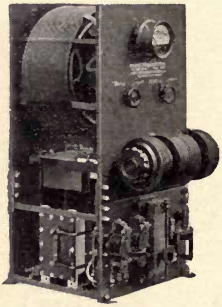


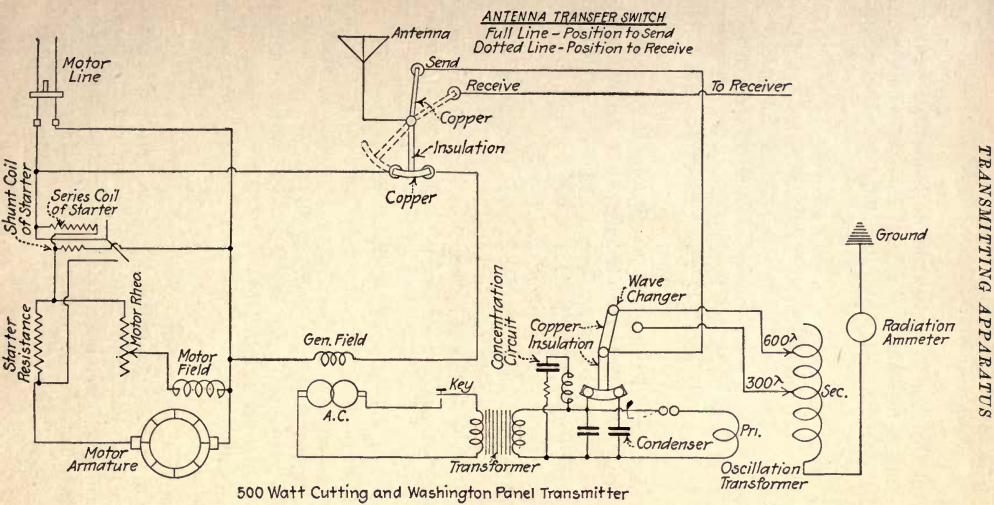
Fig. 10. Cutting & Washington Transmitter

Ans. A modern commercial type of impact excitation transmitter is shown in figure 10. The wiring diagram is shown in figure 11.

Motor Generator. The motor is connected to the regular source of D.C. supply and the alternator delivers 250 volts at 500 cycles frequency.

Transformer. The transformer is a highly efficient one, of the closed core type wound as an auto transformer with a ratio of 5.6:1 and has practically no leakage.

Condenser and Primary Inductance. The total capacitance of the condenser on the ½ K.W. set is .16 mfds., this is automatically decreased when using 300 meters, and the inductance value is approximately 1.2 microhenries. This



500 Watt Cutting and Washington Panel Transmitter

Fig. 11. Wiring diagram Impact Excitation Transmitter

shows that the ratio of capacitance to inductance in an impact excitation transmitter is high. This fact is one of the chief characteristics necessary to get impact or shock excitation.

Spark Gap. The spark gap used with this type of transmitter consists of two electrodes each made of a sparking surface of thin tungsten welded to copper backs and operates in air. The gaps have a micrometer adjustment and the sparking distance may be varied by the thousandth part of an inch. The gaps are provided with cooling fins and locking nuts.

Concentration Circuit. The function of the concentration circuit is to concentrate the discharges into definite groups so that the oscillations upon which the tone is dependent will have approximately equal periods of activity and inactivity, thus giving maximum telephone efficiency.

Oscillation Transformer. The primary consists of a single turn of copper tubing and has an inductance value of 1.2 microhenries as explained before. The secondary consists of 30 turns of edgewise wound strip having a total inductance value of 320 microhenries. The amount of inductance in use, however, will depend upon the size of the antenna.

The term oscillation transformer as applied to impact excitation transmitters is in itself questionable as there are no oscillations in the primary circuit.

A wave changing switch is also attached which is used for changing the wavelength from 300 to 600 meters and which automatically connects in the proper value of capacitance and inductance.

Theoretical Operation. The condenser charges up to a potential sufficient to break down the gap and discharge through the gap. Owing to the low persistence of the primary circuit, the non-volatile nature of the electrodes, the ratio of periods between the primary and secondary circuits and

the pressure-wave generated due to the viscosity of the gas this discharge consists of only a half cycle. This half cycle sets the antenna in oscillation. The condenser then recharges and when it has reached a potential almost sufficient to break down the gap the back E.M.F. from the still oscillating antenna adds an increment to the voltage across the gap sufficient to break the gap down so that this second discharge comes in the proper phase to increase the amplitude of the antenna oscillations. This process continues throughout approximately the middle third of each pulse of the charging

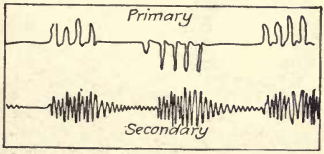


Fig. 12. Impact Oscillations Curve

current. Figure 12 gives a fundamental idea of the oscillations in the primary and secondary circuits and shows that there is no appreciable reaction between the circuits.

A set of the above description can be tuned very quickly and radiates a pure and sharp wave of pleasing tone characteristics.

Ques. 23. What is the difference between an impulse and an impact excitation transmitter?

Ans. According to the latest standardization report of the Institute of Radio Engineers impulse excitation is a term applied to any type of transmitter in which the oscillations of the primary circuit are rapidly damped out and the secondary allowed to oscillate freely in its own natural period without any appreciable reactance between the circuits.

Impact or shock excitation on the other hand means that the gap quenches out the oscillations of the primary before

one or two half cycles of oscillation have taken place. Therefore, any well-designed quenched gap transmitter might be termed an impulse excitation transmitter whereas "Impact Excitation" would imply such a designed set as described in this paragraph.

Ques. 24. What is meant by impact excitation?

Ans. This phenomenon is also termed impulse and shock excitation and designates a method of producing free alter-

Fig. 13. Kolster Decremeter

nating currents in an excited circuit in which the duration of the exciting current is short compared with the duration of the excited current. In a circuit in which such excitation is taking place there is very little reaction between the circuits.

Ques. 25. Describe a form of decremeter. Give diagram and operation.

Ans. A photograph of the latest type direct reading Kolster decrement is shown in figure 13 and the diagram of connections is shown in figure 14 below.

Description. The decremeter consists of a single turn coil I, which is connected in series with the circuit to be measured. The inductance value of this coil is so low as to be negligible. Coil L is placed in inductive relation to coil I and is the inductance of the decremeter circuit. It is important

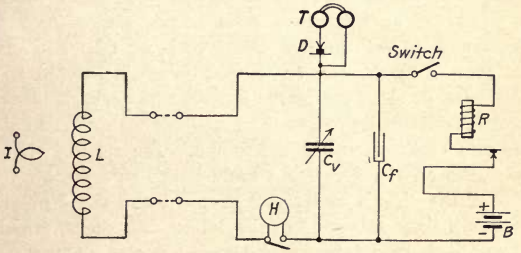


Fig. 14. Wiring diagram Kolster decremeter

that the coupling between coils L and I be at a minimum coupling position when the decremeter is in use. C_v is a variable condenser to which is attached the decremeter scale through gears. A small condenser marked C_f is fixed in value after proper adjustment and is placed in parallel with C_v.

An indicating meter is represented by H. The scale of the meter is so marked that the readings are proportional to the square of the current measured.

If it is desired to measure the wavelength of distant stations the crystal detector D and head telephones T may be used to indicate resonance.

The decremeter may be used for calibration purposes by using the buzzer provided and which is indicated in the circuit as R.B.

Operation. To measure the decrement of an oscillating circuit connect coil I in series with the circuit to be measured as indicated in the diagram. Then rotate the condenser to the position of resonance as indicated by a maximum reading on the current meter. The maximum reading is then reduced to one-half its value by rotating the condenser towards the minimum or maximum ends of its scale. The next operation is to set the decrement scale at zero and clamp it so that when the condenser scale is again rotated it will rotate with it. The condenser is then rotated back until the current meter reading rises from one-half maximum to maximum and back to one-half maximum. The reading now opposite zero on the decrement scale is the sum of the decrements of the circuit under measurement and the decremeter decrement. By subtracting the latter decrement, which is given on a chart supplied with the decremeter, from the sum of the decrements given on the decremeter scale, the decrement of the circuit under measurement can be readily obtained.

Ques. 26. How would the high potential condensers of a transmitting set be protected from puncture?

Ans. Connecting condensers in series divides the voltage between them. It also decreases the capacitance. It is possible then to protect high potential condensers by connecting several units in series, but in order to maintain the total capacitance at a given value it is necessary to connect an equal number of such groups in parallel. Therefore, the series parallel connection as shown in figure 15 is used.

Another method to protect high potential condensers from puncture is to fit the unit with a safety spark gap, figure 16, which is set just below the puncture voltage. This affords

a path for the current to take should that overload value be reached and therefore no damage is done to the condenser.

Ques. 26a. What is the electrical function of the closed core transformer?

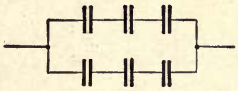


Fig. 15. Series Parallel Condenser Hookup

Ans. The closed core transformer steps up the low voltage, low frequency, alternating current obtained from the motor-generator to a high voltage current of the same frequency which is necessary to charge the primary condenser in the closed oscillating circuit. The condenser discharges through the spark gap, causing the circuit to oscillate at radio frequency. It is necessary to have a comparatively high frequency current to generate ether waves.

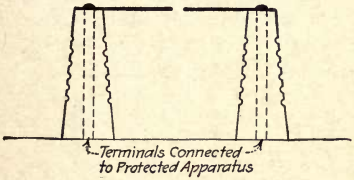


Fig. 16. Protective Spark Gap

Ques. 27. What are three ways in which resonance may be indicated on a wavemeter? Draw diagrams.

Ans. Resonance may be indicated by:

a. Telephone receiver and detector.
b. Current square meter.
c. Glow lamp.

See figure 17.

Ques. 28. Draw a wavemeter with headphones and detector connected unilateraly.

Ans. This is shown in diagram of the Kolster decremeter, figure 14.

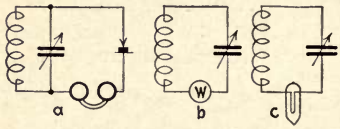


Fig. 17. Wavemeter, methods of resonance

Ques. 29. Is it preferable to connect the condenser across the secondary of the transformer as in A instead of as in B of the figure 18.

There is no difference in practice between these circuits since the inductance of the oscillation transformer is negligible to low frequencies allowing the condenser in both cases A and B to receive a like charge and since during discharge through the gap the inductance of the power transformer is a complete choke to the radio frequencies. Both methods of connection are used in commercial practice.

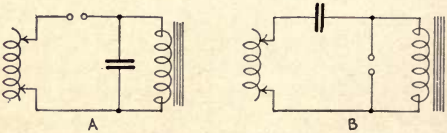


Fig. 18. Condenser to Transformer Connection

Ques. 30. Explain in detail what would happen if one or more condensers were removed from the closed circuit of a transmitter.

Ans. The wavelength of the closed circuit depends, as does any other circuit, upon the capacitance and inductance in the

circuit. Therefore if one or more condensers (capacitance) were removed the wavelength would be reduced accordingly. The resonance of the circuit would also be effected.

Ques. 31. What are the four main circuits of a spark transmitter?

Ans. 1. Low frequency, low potential circuit consisting of; all apparatus from A.C. generator to primary of power transformer.

2. Low frequency, high potential circuit consisting of; secondary of power transformer and condensers.

3. High frequency, high potential closed oscillatory circuit. It consists of the condensers, spark gap, and primary of oscillation transformer.

4. High frequency, high potential open oscillatory circuit. It consists of antenna, loading inductance, secondary oscillation transformer, and ground.

Ques. 32. Describe a frequency meter.

Ans. A widely used frequency meter is the Hartman and Braun vibrating-reed type. It consists essentially of an electromagnet in front of which is fixed a series of reeds tuned to given frequencies. When an alternating current flows through the magnet, the reed tuned to that frequency vibrates. A scale is arranged so that the frequency which a given reed indicates may be read directly.

Ques. 33. Explain the action, in the closed oscillatory circuit of a transmitter, when the key is pressed.

Ans. When the key is pressed current flows from the A.C. generator through the primary of the step up power transformer setting up a magnetic field around it. The rising and falling of the magnetic lines of the primary cut the secondary windings inducing an E.M.F. therein and raising it to a very high voltage. The high potential condensers are charged to the break-down potential of the gap, resulting in a discharge. The circuit through which the discharge takes

place, having capacitance and inductance, has oscillatory characteristics and the spark discharging through it sets up oscillations. The spark oscillations in turn have a wavelength depending upon the capacitance and inductance of the closed circuit. The oscillations in the closed circuit induce oscillations in the open oscillating circuit at the wavelength to which this circuit is tuned. The oscillations in the open circuit are radiated out into the ether in the form of electromagnetic waves.

Ques. 34. Describe the open and closed core transformer.

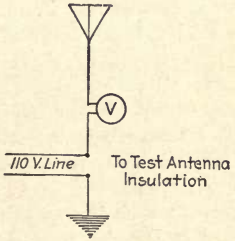
Ans. An open-core transformer has a core made of soft iron in strip or wire form. To decrease losses the individual wires or strips that constitute the core are shellaced. An insulation wrapping is wound around the core and the primary winding of a comparatively few heavy turns is wound around it. A heavy insulation is placed over this winding and the secondary winding of many turns of fine wire is wound thereon in pan-cake form. The path of the magnetic field in an open core transformer is open as will be seen by referring to the upper transformer figure on page 8. It is seen that the field path is completed through the air.

The closed-core transformer is shown below the open core figure on page eight. The core of this type takes the form shown in the figure and may be built up in the same way explained for the open core type. The windings are also of similar characteristics. The magnetic field path is closed through the core, hence the name closed-core transformer.

Ques. 35. Show by diagram how an antenna may be tested for grounds.

Ans. Ground leaks in antenna insulation may be detected by connecting a voltmeter in series with antenna and applying a 110-volt current as shown in the diagram on the next page. If no deflection is shown by the meter the insulation is good, if the meter indicates a flow of current (de-

flects), the insulation is faulty and should be remedied. A practical method used by radio-operators and inspectors on shipboard is to transmit on full power and watch closely for arcing in the antenna circuit and antenna proper. The radiation ammeter will not register if the antenna is badly grounded.



Part III

ARC TRANSMITTERS

Ques. 36. How would you proceed to place an arc transmitter in operation? Explain fully.

Ans. To place an arc transmitter in operation it is important to see that the alcohol cup is full and that it feeds properly. The water tank should be about three-quarters full with fresh water and all valves opened. Notice should be taken that the water circulates properly when the pump is started. To start transmitting, the following operations should be gone through in their regular order, viz.:

1. Close set supply switch.

2. Throw changeover switch to transmitting position. Note that pump is started and that carbon electrode is rotating.

3. Start motor generator by closing main-line circuit breaker and bringing motor slowly up to full speed with starting rheostat. Adjust generator voltage to about 250 volts by adjusting field rheostat.

4. Start alcohol dripping rather rapidly. Bring electrodes about 1-32 inch from each other.

5. Close the arc main-line switch and strike the arc. Carefully adjust for maximum arc length without causing the arc to break. It will be necessary to allow a sufficient amount of alcohol to decompose and give a hydrogen atmosphere so that the arc will burn steadily. For this reason do not draw out the arc for one or two minutes the first time the set is started. When the radio-frequency ammeter starts reading, it indicates that the arc is oscillating and the arc starting resistor switch should be closed and the arc adjusted for

maximum radiation. The alcohol feed may now be slowed down and only enough alcohol allowed to drip to maintain maximum radiation. Signals may now be sent by manipulation of the telegraph key.

Ques. 37. Draw an elementary diagram of an arc transmitter, including source of power.

Ans. See figure 19 below.

Ques. 38. Of what material are the negative and positive electrodes made?

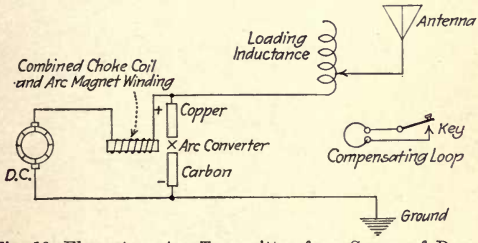


Fig. 19. Elementary Arc Transmitter from Source of Power

Ans. The positive electrode is made of copper and the negative electrode is made of carbon.

Ques. 39. Why is the negative electrode slowly rotated?

Ans. This is done so that the carbon material of which the electrode is made will burn evenly.

Ques. 40. What means are provided for keeping the electrodes of an arc transmitter cool? Explain fully.

Ans. The copper electrode is hollow and water is circulated through it. The arc chamber is also provided with an exhaust path for allowing the carbonized hydrogen gas in the arc chamber to escape. These characteristics in the design of the arc tend to keep the electrodes cool.

Ques. 41. Explain two ways of cooling an arc.

Ans. This is explained in the above question.

Ques. 42. Explain how to obtain maximum voltage across the arc.

Ans. This is accomplished by carefully adjusting the arc length and voltage, by turning the electrode adjusting handle and by means of the field rheostat. It is also necessary that the electrodes be in good condition.

Ques. 43. Describe the construction of the positive electrode of the arc.

Ans. The positive electrode of the arc is copper. It consists of a copper tip which is fastened to a brass holder. It can be removed from the holder when it has burned low. The tip is so constructed that water can flow through it, thereby

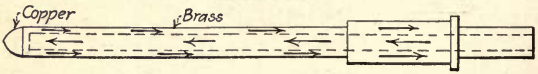


Fig. 20. Positive Electrode, Arc

keeping it cool. The figure 20 shows the water circulation and general construction of the positive electrode.

Ques. 44. How would you adjust the flow of water to the cooling chamber?

Ans. The flow of water can be adjusted by regulating a valve near the water tank.

Ques. 45. What is an arc?

Ans. The Committee on Standardization, Institute of Radio Engineers, defines the arc as the passage of an electric current of relatively high density through a gas or vapor, the conductivity of which is mainly due to the electron emission from the self-heated cathode. Under present practical conditions, the phenomena takes place near atmospheric pressure. A transmitting system using an arc for producing the undamped oscillations is sometimes referred to as an "arc" or an arc set.

Ques. 46. Of what materials are the electrodes in an arc transmitter composed?

Ans. The positive electrode is made of copper and the negative electrode is carbon.

Ques. 47. Draw an elementary diagram of an arc transmitter. Explain fully its operation.

Ans. For elementary diagram of arc see Fig. 21.

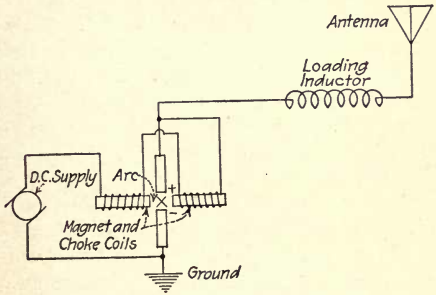


Fig. 21. Fundamental Arc Transmitter

The arc is fed by a direct current varying in pressure from 200 to 1200 volts, depending upon its size. To this source of supply is connected the arc converter where the supply current is converted into high frequency, undamped etheral oscillations in the following manner.

a. The arc is struck and the high potential current across the terminals begins to charge the condenser. Therefore, the condenser takes some of the current away from the arc and the voltage across the arc increases until the condenser is fully charged.

b. When the condenser is fully charged the current through the arc rises to normal value, this causes the volts across the arc to drop. However, the condenser is still fully

charged and its voltage value is now higher than that of the arc. It therefore discharges across the arc.

c. Due to the fact that the discharge takes place through a circuit having oscillatory characteristics, undamped etheral oscillations are produced.

d. At each oscillation the volts rise and fall periodically, giving a constant source of energy. Therefore, as long as the voltage is present the oscillations continue.

Ques. 48. What are the advantages of undamped waves?

Ans. Some of the principal advantages of undamped waves are due to the perfect syntony obtainable. This permits close tuning and reduces interference between stations which are close together. The detector arrangements used for the reception of undamped waves have better mechanical features than the crystal detector used for damp wave reception and are not so easily put out of adjustment.

In spark systems there are groups of oscillations separated by comparatively long intervals of inactivity, so that if high speed transmission is attempted there are not many trains of oscillations per dot or dash, whereas with undamped oscillations these periods of inactivity are absent, hence high-speed work is possible as soon as reception apparatus has been developed which will be automatic and efficient.

Wireless telephony has been more successfully developed with undamped waves due to the persistency of the voice-carrying waves.

With given power much greater distances are covered with undamped waves than with damped waves.

Another feature bearing on the greater efficiency of undamped waves, is the fact that longer waves can be employed with this type of apparatus, thus reducing absorption.

Part IV

STORAGE BATTERIES

Ques. 49. What is an underload circuit breaker?

Ans. It consists of a solenoid switch which is connected in series to the lines to be protected. Its position is shown in figure 43, marked Low Voltage Release.

An underload circuit breaker is used on storage battery charging panels to open the circuit should the voltage of the generator fall below the voltage of the battery being charged. This prevents the battery from discharging back into the generator, thus preventing possible damage of the generator as well as to the battery itself.

Edison Cell

Ques. 50. What is the charging voltage of an Edison Cell? What is voltage of charged cell? What is discharge voltage for the normal functioning of cell? What is voltage of a discharged cell?

Ans. Charging voltage is 1.85 volts. Full charge voltage is 1.8 volts. Normal discharge voltage is 1.2 volts.

Final useful cell voltage at normal rate is .9 volts (Edison cells may be discharged to any voltage down to zero, at any rate, and suffer no harm, so long as temperature does not exceed 115 degrees Fahr.)

Ques. 51. How is the extent of charge of an Edison cell determined? Explain fully.

Ans. By taking voltage reading on normal rate discharge and comparing it with the normal charge voltage curve. For commercial practicability the ampere hour meter is used with all kinds of batteries. It is particularly to be remembered

that the extent of charge of an Edison cell cannot be determined by taking a hydrometer reading, as the specific gravity of the electrolyte in this type of cell does not vary with charge and discharge.

Ques. 52. What effect will charging an Edison cell have on the electrolyte?

Ans. No effect, beyond losing some water by electrolysis, which is replaced by flushing with distilled water.

Ques. 53. Of what material is the positive and negative plates of the Edison cell made?

Ans. The material in the positive plate consists of alternate layers of nickel hydroxide and exceedingly thin flakes of pure nickel.

The negative plate material is powdered iron oxide with a small percentage of mercury added to increase conductivity.

Ques. 54. Of what is the electrolyte of the Edison cell composed?

Ans. The electrolyte consists of a 21 per cent solution of Potassium Hydrate in distilled water with a small percentage of lithium hydrate having a specific gravity averaging 1.200. The electrolyte does not vary in density during charge and discharge. The Edison electrolyte preserves the steel plates. Unlike the lead-acid battery, the active materials are not attacked, or eaten away by the electrolyte.

Ques. 55. What would be the effect of charging an Edison cell in the wrong direction? What would be the effect on a lead cell?

Ans. There would be no damage done to the Edison cell if the temperature did not rise above 115 degrees Fahr. The only effect would be that the cell would act as an electrolytic gas generator accumulating only a very slight charge in the reverse direction.

If a lead cell is charged in the reverse direction it would result in severe buckling of the plates, loosening of active

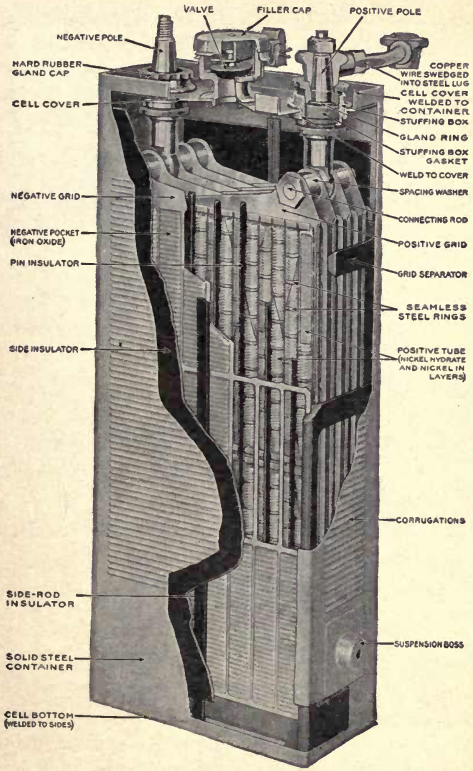


Fig. 22. Cross section Edison Cell

material and complete disruption of internal cell parts. The meters on the board would indicate trouble. In all modern battery equipments a circuit breaker, or fuses in small in-

stallations, is connected in the circuit which protects against such things as charging in the reverse direction.

Ques. 56. Explain construction of an Edison cell.

Ans. The following brief explanation of the Edison cell may be better understood by referring to figure 22.

POSITIVE PLATE. The positive plate consists of heavily nickel plated perforated steel tubes arranged in rows and filled with narrow layers of nickel hydroxide, and exceedingly thin flakes of pure nickel.

NEGATIVE PLATE. The negative plate consists of a grid of nickel plated cold rolled steel holding a number of rectangular perforated pockets filled with powdered iron oxide.

ASSEMBLY. The plates are separated by narrow pins of especially treated hard rubber which is not injured by electrolyte. The end insulator is provided with grooves that take the edge of the plates, spacing and insulating them from the steel container.

ELECTROLYTE. The composition of the electrolyte is explained under question 54.

Ques. 57. Can the state of charge of an Edison cell be determined by means of a hydrometer?

Ans. No. See question 51.

Ques. 58. What instrument should be used to determine the amount of charge of an Edison cell? Why?

Ans. The Voltmeter. Because the voltage of the Edison cell is the only measurable difference between the condition of the cell when it is fully charged and when it is discharged. Also the ampere hour meter may be used. (See question 51). A hydrometer should never be used because the specific gravity of the electrolyte does not vary with the degree of charge.

Ques. 59. What is the specific gravity of the electrolyte in an Edison cell? Does this vary with charge and discharge?

Ans. The specific gravity of the electrolyte averages 1.200. The specific gravity of the electrolyte does not vary appreciably with charge and discharge; the small loss is due to electrolysis.

Ques. 60. Is there any action in the electrolyte of the Edison cell?

Ans. Yes. As this action is a chemical one and would require that the reader have a knowledge of chemistry, an explanation is omitted from this page and given in the appendix 1.

Ques. 61. How do you treat a storage cell that shows signs of sulphation?

Ans. This applies to lead cells only, the entire bank containing the sulphated cell should be subjected to a long, heavy charge. If the sulphation is not serious this treatment will restore the afflicted cell to normal condition. It is best if one or more individual cells appear sulphated while the rest of the battery is in good condition, to remove such cells and treat them separately by giving them a charge at a high rate. If the specific gravity of the electrolyte of a cell under treatment for sulphation rises above the normal level, remove some of the electrolyte and replace by pure water until the proper density is secured. Sulphated plates should be handled as little as possible.

Ques. 62. At what temperature does a storage battery work best?

Ans. Seventy degrees Fahrenheit, air temperature.

Ques. 63. Tell the care necessary to place a lead acid battery out of service for an indefinite period.

Ans. If the battery is to be put out of service for less than a year it should be put into what is called wet storage.

This is the method usually applied to radio batteries provided, of course, they do not require repairs that will necessitate dismantling. To determine this a careful examination of a specimen cell in the battery is necessary. To place a battery in wet storage it is given an equalizing charge and stored away where it will be free from dust. The level of the electrolyte during the period the battery is in storage must be constantly maintained about one-half inch above the tops of the plates by the addition of distilled water. During the storage period the battery should be given a charge every four months until the cells gas for at least three hours. Any cells not gasing should be examined and remedied.

To place a battery in dry storage it is necessary to completely dismantle the various parts and as this is the work of a battery expert it should not be attempted by the layman.

NOTE: Those interested may obtain a pamphlet from the Electric Storage Battery Company of Philadelphia giving full directions for placing storage cells in storage.

Ques. 64. What precaution should be taken in connection with combining sulphuric acid and water?

Ans. Always pour the acid slowly into the water. Never pour the water into the acid as a violent chemical action takes place which causes the mixture to boil so violently as to do damage.

Ques. 65. State fully the care to be given a sixty cell Exide battery equipment such as is used on shipboard.

Ans. A battery equipment regardless of type should have careful attention. The electrolyte should be kept about one-half inch above the top of the plates by replacing loss due to evaporation with distilled water. The electrolyte level should never be maintained by replacing acid unless the electrolyte is in some way spilled out. The acid does not

evaporate, it being the water in the electrolyte that is so reduced. It is important that the battery be kept fully charged, not only so that it may be ready for immediate use, but it is best for the internal condition of the individual cells that they be so kept. The condition of charge of a lead cell battery may be checked up by taking combined hydrometer and voltmeter readings of the individual cells. If the cells as a whole show a comparatively low reading it shows that they should be charged. The low voltage reading indicates the same condition. Radio batteries should be given a check up about once a month. If a cell shows an unnatural condition such as low specific gravity reading and low voltage reading it may indicate sulphation or plate buckling and it should be cut out of the circuit by disconnecting the lead strap connectors and jumping the bad cell. As soon as possible the bad cell should be taken out and repaired. The battery should be promptly recharged when the voltage of the individual cell reaches 1.7 volts, therefore the voltage of the entire bank would read 1.7 $\times$ number of cells. A battery should not be charged more frequently than once a week unless the service requires it. A few simple rules listed below apply to all cells.

a. Keep open flames away from the battery at all times.
b. Replace electrolyte before charging.
c. When water in cell evaporates add distilled water.
d. Never allow cells to remain in discharged condition.
e. Mix electrolyte in clean earthen or glass jars.
f. Allow solution to cool before putting into cell.
g. Never pour water into sulphuric acid.
h. Never allow salt to get into cell.
i. Use only absolutely pure chemicals and water.
j. Always provide plenty of ventilation.
k. If burned by sulphuric acid apply ammonium hydroxide or soda.

Over sulphation may be caused by:

1. Wrong specific gravity of electrolyte.
2. Overdischarge.
3. Allowing cell to remain too long in a discharged condition.

Ques. 66. What determines the capacity of a storage cell? What is the unit of capacity of a cell?

Ans. The capacity of a storage cell is determined by the number of plates and by the amount of available active material contained in the individual cells.

The unit of capacity is the ampere hour. A battery is rated as having so many ampere hours capacity.

Part V

MOTORS AND GENERATORS

Ques. 67. Describe a compound wound motor. Where is the rheostat controlling the speed regulation connected in a compound motor?

Ans. A compound motor has both series and shunt field coils. The shunt field is wound with small wire and the series field is wound with heavy wire. The series field is in series with the armature and the shunt field is connected in shunt or parallel to the armature. A wiring diagram of a compound motor is shown in figure 23. A cut of a compound motor field coil is

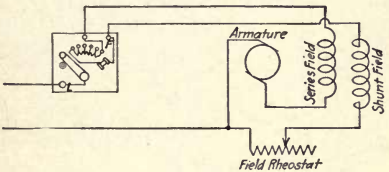


Fig. 23. Wiring Diagram Compound Motor

shown in figure 24. Note the heavy series winding on the end of the core. The shunt winding takes up most of the winding space. The rheostat controlling the speed is connected in the shunt field as shown by the diagram.

Ques 68. What will cause a motor and also a generator to overheat?

Ans. Overheating of motors and generators is usually caused by either lack of oil on the bearings or overloading the machine. Grooved bearings or a sprung shaft may cause heating.

Ques. 69. If a generator field burned out what would be the effect?

Ans. No E. M. F. would be generated.

Ques. 70. What is the difference between a motor and a generator?

Ans. A motor is a machine for transforming electrical energy into mechanical energy. A generator (A.C. or D.C.) changes mechanical energy into electrical energy.

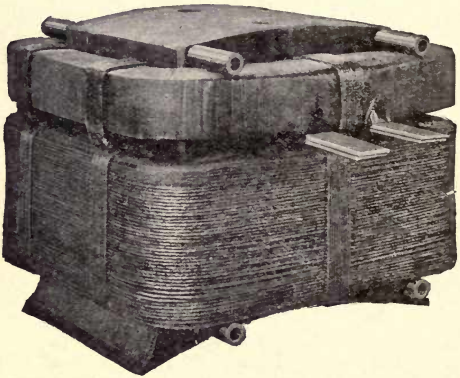


Fig. 24. Field Coil Compound Motor

Ques. 71. What is the difference between an A.C. generator and a D.C. motor?

Ans. Aside from the difference noted in the question above an A.C. generator may have slip rings and a D.C. motor always has a commutator. There is also, of course, a difference in the electrical design.

Ques. 72. How are the fields of a generator generally excited?

Ans. In radio practice the field of the generator or alternator is usually separately excited as shown in figure 25, by connecting the field directly in parallel to an external source of direct E.M.F.

Ques. 73. How is the voltage of a generator increased?

Ans. The voltage of a generator may be increased by increasing the field excitation. This may be done by decreasing the resistance of a field rheostat which controls the current flowing into the generator field.

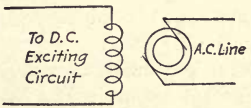


Fig. 25. Separately excited generator field

Ques. 74. Explain fully, no load and full load voltage.

Ans. **No Load Voltage** is the pressure generated when the machine has no external load. In radio transmitters, this is the condition when the key is not closed. This value is the one given as the rated voltage of the machine, for example: a 110 volt generator gives 110 volts on no load.

Full Load Voltage is the resultant pressure when the machine is connected to an external load. When a load is placed on the machine the voltage drops to a lower figure, depending upon the load value. This is illustrated when the key to a transmitting set is closed and the voltage of the generator immediately drops to a lower value depending upon the power being used.

Ques. 75. An alternator has 24 poles and a speed of 3600 R.P.M. What is the frequency?

Ans. The frequency of the generator may be found by multiplying the number of pairs of poles by the revolutions per second. In this case, if there are 24 poles, there are 12

pairs of poles. If the speed is 3600 R.P.M., the speed per second would be 1/60 of that or 60 R.P. Second. Therefore the frequency is Pairs of Poles 12 $\times$ 60 = 720 or Answer: 720 cycles.

Ques. 76. Give the function of the commutator of the D.C. motor.

Ans. The function of the commutator of the D.C. motor is to maintain proper direction of armature current under each field pole. As the various armature conductors pass from one pole to the next, the direction of current flow is thus automatically changed, resulting in a constant turning effort (torque) in one direction.

On a generator the commutator commutes or rectifies the induced E.M.F. in the armature conductors and conveys the E.M.F. to outside conductors in one direction only.

Ques. 77. What is the effect of starting a motor too suddenly or too slowly?

Ans. Starting a motor too quickly will cause the breakers to trip or the fuses to blow. This is due to the low resistance of the armature circuit and lack of counter E.M.F. before it comes up to speed. If there were no fuses or breakers in the line the armature winding would burn out.

Starting a motor too slowly may burn out the resistance units in the starting box as they are made for temporary duty only and cannot stand a heavy current flow for more than a very short period.

Ques. 78. Why are collector rings used on an alternator?

Ans. The function of the collector rings is to conduct the alternating E.M.F. induced in the armature coils to outside conductors.

Ques. 79. What is a water rheostat?

Ans. A water rheostat consists of a container, made of insulating material such as wood or fibre, filled with salt water into which are placed three plates. This arrangement

is placed in the circuit as shown in figure 26, and the resistance varied by making the distance between the plates greater or smaller, respectively, for high or low resistance. As an example, if such a rheostat is used in place of the starting box in a shunt motor circuit, the plates are first put in such a position that the plate A is nearest plate B. In this position the resistance in the field circuit is at a minimum and allows

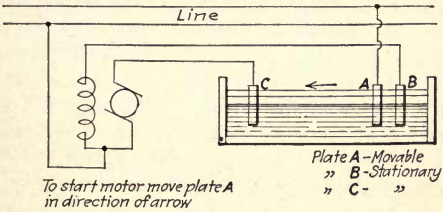


Fig. 26. Water Rheostat

a strong current to flow in the field while the conditions in the armature circuit are the reverse.

Plate A is at a maximum distance from plate C and a maximum resistance value is in the armature circuit allowing only a small current to flow which is desirable when starting a motor. The movable plate A is then moved in the direction of the arrow toward C and the resistance in the field circuit is increased, decreasing the field current, while the resistance in the armature circuit is decreased, increasing the armature current as the plate A approaches plate C and as the motor gains speed.

A water rheostat may be used in an emergency when other rheostats are burned out or out of order. This type of rheostat is also used in electrical laboratories.

Ques. 80. What is the no-field-voltage release magnet, and where is it placed?

Ans. The no-voltage release is incorporated as part of the starting box. It is a small electromagnet and is placed in such a position that when the handle of the starter is in full running position it is held in that position by the magnetic attraction of the no-voltage release. The winding of the no-voltage release is placed in series with the field winding of the motor. If the field winding circuit is opened in any way the starting box handle springs back to starting position. This action safeguards the machine from being burned out; for if the starting handle remained in full-speed position and the current were suddenly turned on when the motor was stopped, the sudden inrush of current to the motor armature would burn it out because there would be no counter E.M.F. generated to buck the incoming current and to hold it to safe limits. The no-voltage release is shown in figure 23.

Part VI

RECEIVING APPARATUS

Ques. 81. What means are provided in a receiving system to protect it from injury by signals transmitted on high power in the nearby vicinity?

Ans. A safety gap of very short length is connected between the antenna and the ground on receiving equipment at the point where the antenna lead and the ground lead make connection to the apparatus. Strong signals will discharge across the gap and form a short path to the ground and in that way they are prevented from passing through the receiving apparatus and can do no damage to it. Some types of receivers are fitted with a very high resistance conductor which is connected directly across the antenna and ground. Such a protective device allows currents of such value as to be of a damaging nature to pass directly to the earth. It is of course possible in inductively coupled types of apparatus to quickly decrease the coupling and in that way the mutual induction between the circuits is decreased so that the high potential current does not flow through the secondary circuit where it might do damage.

Ques. 82. Describe a receiving system employing hetrodyne principles.

Ans. There are two kinds of hetrodyne receivers, viz.: External hetrodyne and self-hetrodyne. The former is not used to any extent at the present time having been superseded largely by the latter. One type of self-hetrodyne is shown in figure 27. Coil L_2 is coupled to a primary coil in the antenna circuit.

The important feature of this hookup is that the plate is coupled to the grid circuit through the inductance L_1 reacting on L_2.

Ques. 83. Draw a diagram of a receiving system employing audion tubes; (a) As a detector, (b) With one step of amplification, (c) With two steps of amplification.

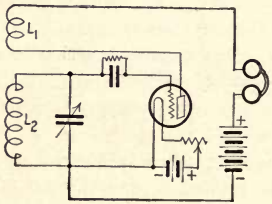


Fig. 27. Self Hetrodyne

Ans. See figures 28, 29 and 30 below. The inductance, figure 28, is coupled to a primary coil in the antenna circuit when receiving distant signals.

Ques. 84. How would you adjust a receiving system employing an audion detector to the given wavelength of a transmitter?

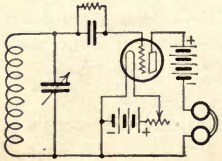


Fig. 28. Audion Detector

Ans. To adjust an audion detector receiver to a given wavelength, light the filament by closing the filament circuit switch. Care must be taken not to burn the filament too brightly as the strength of the signals do not always increase

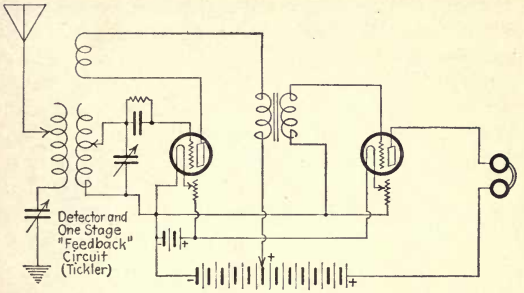


Fig. 29. One Step Amplifier

with filament current. Next close the B battery switch and adjust the secondary and primary circuits to the desired wavelength. If no signals are heard it may be that the polarity of either the filament or plate battery is reversed, the remedy in this case is to change the connections.

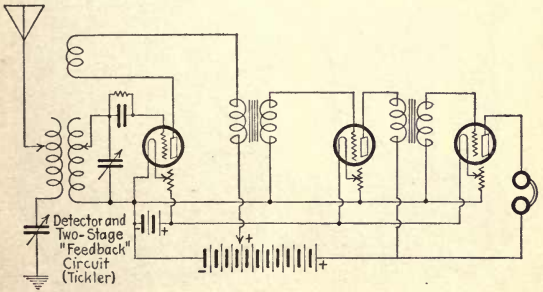


Fig. 30. Two Step Amplifier

Ques. 85. Draw a diagram of a standard receiving circuit employing a crystal detector and potentiometer.

Ans. See figure 31 below.

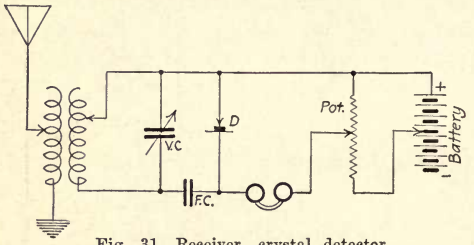


Fig. 31. Receiver, crystal detector

Ques. 86. Describe a variometer to be used in connection with a receiving system.

Ans. The variometer consists of two hoop form coils of wire wound on forms. One of the coils is stationary and the other moves inside the stationary coil. The two coils are con-

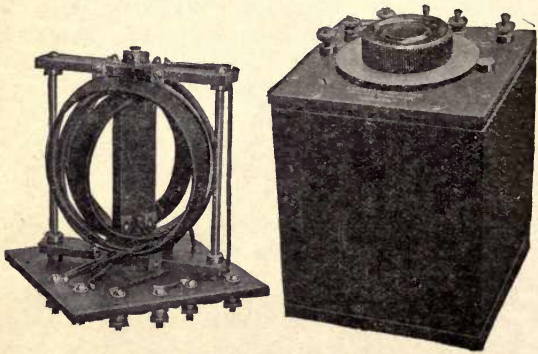


Fig. 32. Variometer
(Courtesy, General Radio Co.)

nected in series. Figure 32 shows a form of variometer. The movable coil has a scale attached on the top of the cabinet which shows the relative positions of the coils. When the coils are in a position so that their magnetic fields buck one another the inductance is at a minimum. The advantage of the variometer is that there are no movable switches to be adjusted when tuning. A very fine variation of wavelength is possible.

Ques. 87. Show by diagram two means of connecting a test buzzer to a crystal detector. Explain their advantage and connection fully.

Ans. See figure 33 below.

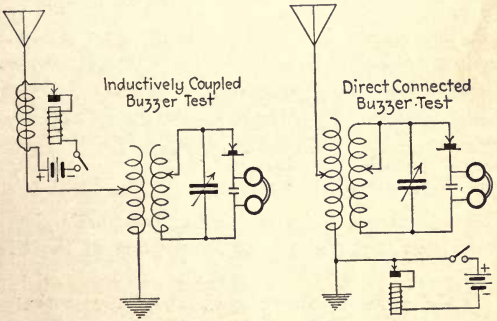


Fig. 33. Buzzer Detector Tester

A test buzzer connected as in figure 33, if connected inductively or directly is of advantage in testing whether or not the receiving apparatus as a whole is in working condition. This function can be performed by a test buzzer because it generates electromagnetic waves which have an effect upon the receiving cricuit similar to the electromagnetic waves received from a distant transmitter. A test buzzer is of very

great value when a crystal detector is used as it is the only absolute method of making sure that the detector point is on a sensitive spot on the crystal.

Ques. 88. What is the meaning of the term "stand by" circuit in connection with a receiving system.

Ans. A "stand by" circuit is one that is tuned broadly. With a circuit of this kind a wide range of wavelengths can be heard and for this reason it is valuable for general listening in.

Ques. 89. Why is it necessary to employ a diaphram in connection with head receivers?

Ans. It is the vibration of the diaphram that produces the sound in the head receiver. The diaphram is acted upon by the magnets in the receiver and vibrates at a certain speed depending upon the frequency of magnetic attraction exerted by the magnets. High frequency of vibration gives a high tone and likewise low frequency gives low tone. In spark transmitters the received tone is directly dependent upon the spark frequency. In undamped systems the tone may be varied at the will of the operator.

Ques. 90. Describe the electrical and magnetic phenomena in connection with the proper functioning of the head receiver.

Ans. In order to clearly understand the working of a telephone receiver it is necessary to know the principal parts of which it is composed. Figure 34 shows a side cut of a watch case type such as is used in radio work.

Note that the diaphram is placed so that it will be affected by the magnets. The magnets are permanent electromagnets and the magnetism in them has a holding effect on the diaphram. However, a more pronounced movement of the diaphram towards and away from the pole pieces takes place when a pulsating E.M.F. is applied to the coils. When no

current is flowing in the magnet coils the position of the diaphram is as in position A, which is normal.

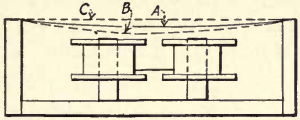


Fig. 34. Telephone Receiver

When the current flows through coils a magnetic field is set up which draws the diaphram towards the pole faces position B. When the current stops the diaphram returns to normal position, but may spring back to position C. It is seen that every time the diaphram moves from normal position to the position nearest the pole faces and back to normal a click is produced. If these clicks are made to occur in rapid succession a continuous sound is produced. A study of the graphs, figure 35, will show the relation of the ether oscillations to the final telephone current.

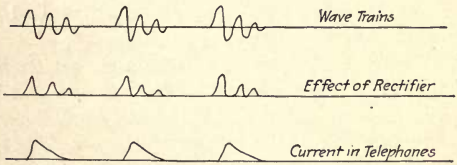


Fig. 35. Wavetrain to Telephone Current Curve

If the spark frequency is steady and the sparks discharge across the gap at regular intervals the note in the headphone will be smooth. If, on the other hand, the intervals between the sparks are uneven, an uneven note will be heard in the head receiver.

Ques. 91. Describe magnetic coupling. Describe electrostatic coupling.

Ans. **Magnetic Coupling** is any coupling which takes place by means of magnetic lines of force. The autotransformer is used to give direct magnetic coupling and the oscillation transformer gives inductive magnetic coupling. Both are types of magnetic coupling. See figures 36a and b. The term

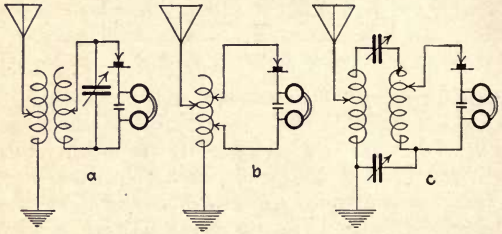


Fig. 36. Magnetic and Static Coupling

electromagnetic coupling is used synonymously with magnetic coupling. Electrostatic coupling takes place through a condenser as shown in figure 36c.

Ques. 92. Describe what happens to a wave train when it strikes the receiving aerial.

Ans. When an advancing wave train strikes an aerial it cuts the wires of which the aerial is composed and induces an E.M.F. therein. This E.M.F. causes oscillations in the aerial circuit as long as the cutting continues. There is connected in the aerial circuit directly or by means of inductive coupling a detector or rectifying instrument which breaks up the antenna oscillations into a series of low frequency unidirectional pulses which are audible in the telephone receiver.

Ques. 93. How do you proceed to calibrate a receiving set with a wavemeter?

Ans. To calibrate a receiving set the wavemeter must act as a transmitter. This is accomplished by means of a buzzer

as shown in figure 37. First start the buzzer and tune the wavemeter to the lowest wavelength to which the receiving set is to be tuned. Tune the primary circuit of the receiver to resonance with the wavemeter by varying any movable inductance or capacity handles in the circuit and note the final positions on a sheet. The secondary or closed circuit may then be adjusted until the loudest signal is heard. This is done by moving inductance switches and condenser handles. The final positions of each can be noted on a sheet. The

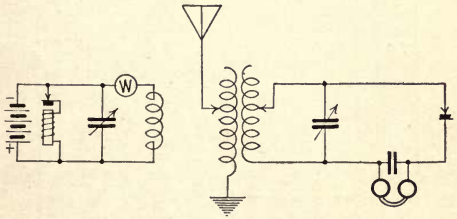


Fig. 37. Tuning Receiver with a Wavemeter

wavemeter may now be tuned to the next higher wavelength and a similar operation gone through. These operations to be repeated for each successive wavelength.

The wavemeter must be placed in close proximity to the receiver and coupled to it as shown in the diagram. A sample tuning sheet is shown in figure 38.

Ques. 94. Describe and explain the operation of a Poulsen ticker.

Ans. **A Poulsen Ticker** consists of a segmented wheel with certain segments electrically connected together so that a conducting path is connected between stationary brushes at predetermined intervals. This wheel is mounted on a motor shaft and connected in place of the detector in the receiver circuit and serves to break up undamped oscillations into low frequency groups so they may be audible in the headphones.

Ques. 95. Describe the operation of the slipping contact detector.

Ans. A **Slipping Contact Detector** consists of a grooved brass wheel mounted on a motor shaft. A wire brush is so arranged as to make slipping contact when the wheel rotates. The wheel and brush connections are connected in place of the

Wave Length	Primary	Primary Cond.	Secon-dary	Secondary Cond.	Coupling
200					
250					
300					
350					
400					
450					
500					
550					
600					
650					
700					
750					
800					
850					
900					
950					
1000					

Fig. 38. Tuning Sheet

crystal detector. The theory of operation is that the slipping contact is one of variable resistance and therefore causes variable charges to accumulate in the telephone condenser. The note in the headtelephones will vary in accordance with the speed at which the wheel rotates.

Ques. 96. Why is it necessary to employ detecting elements to render radio signals audible?

Ans. Electrical ether waves have a frequency from 20,000 cycles up. Frequencies above this limit are ordinarily inaudible. If the headtelephones were energized by the frequency direct and the diaphram vibrated at this frequency, nothing would be heard as it is above audibility. It is therefore necessary to rectify these high frequency oscillations into

a pulsating E.M.F. which can be heard in the headphones. This rectification is shown graphically in figure 35.

Ques. 97. Why are permanent magnets used in headtelephones?

Ans. Permanent magnets produce a greater response for a given current than is obtained with soft iron magnets.

Ques. 98. How would you test for a short circuit in an air dielectric condenser?

Ans. A low potential condenser with air dielectric may be tested for a short circuit in several ways. One of the simplest would be to connect the condenser under test in parallel to the headtelephones, leaving one side of the circuit loose so that it can be connected and disconnected quickly. When radio signals are heard if the parallel condenser circuit is completed and the condenser is not short circuited, signals will be heard as before. This test can only be used where it is possible to receive loud signals as the capacity of the condenser across the headtelephones may render weak signals inaudible. Another and more simple test would be to insert a headphone and dry cell in series with the condenser and if short-circuited, a click would be heard in telephones.

Ques. 99. Explain how you would tune in signals with an inductively coupled receiver.

Ans. A simple inductively coupled receiver is shown in figure 39. To receive signals make sure the antenna and ground connections are made. Set the crystal detector D to a sensitive position as determined with the aid of a test buzzer. Set the variable condenser V.C. near the minimum value and closely couple the secondary S to the Primary P. Listen carefully and vary the contact 1 until the maximum signal is heard. Next vary the inductance value of the sec-

ondary by moving the contact 2 until the signal strength is increased to a new maximum. The variable secondary condenser V.C. may now be varied for maximum signal strength. If interference from other stations is heard, the coupling should be decreased by moving the secondary away from the primary. It is well to remember that generally louder signals are obtained with a maximum value of secondary inductance and a minimum value of secondary capacity. To avoid inter-

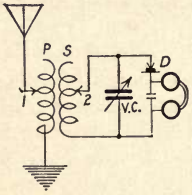


Fig. 39. Inductively Coupled Receiver

ference from other stations, work with the smallest degree of coupling possible.

Ques. 100. Why are low resistance phones not used with any type of modern detector?

Ans. The current flowing in the telephone circuit of a radio receiving set is of very small value. In order that a strong electromagnetic field may be generated by this feeble current, a great number of turns of wire must be included. To illustrate, let us assume that a force strong enough to lift 100 lbs. must be produced by a given magnet. If one turn produces a force strong enough to lift one pound, more turns would be necessary for the magnet desired. Therefore adding ampere turns increases the magnetic power of a magnet.

To apply the above example to radio receivers it is readily seen that in order for the very feeble currents flowing in the

telephones circuit to produce a strong field, a great many turns of wire must be wound on the magnet. All wire has resistance, therefore, relatively speaking, a telephone with a great number of turns such as is needed in radio will have a high resistance. Low resistance telephones have less turns and therefore less ampere turns than high resistance phones, therefore, the latter are desirable for use with radio detectors. Commercial receivers of today are wound between 2000 and 3000 ohms.

Ques. 101. What is the function of a fixed condenser in a receiving circuit?

Ans. The fixed condenser is usually connected in parallel to the telephones. In this position it provides a complete circuit for the oscillations in the secondary circuit without having to flow through the telephones, the high induction of which would tend to choke back the oscillations and possibly prevent their detection.

Ques. 102. Explain how a buzzer tester may be used to locate faults in a receiving circuit.

Ans. If a certain part of the receiving apparatus is suspected of being open circuited or short circuited, a buzzer tester may be used to locate the trouble. To test for an open or short circuit connect the buzzer in series with the circuit under test. If the buzzer operates, the current path is complete, if it does not, the current path is open. An open circuit is indicated by lack of operation of the buzzer. A closed circuit is indicated by operation of the buzzer. The test may be applied to each piece of apparatus separately until the trouble or series of troubles is located.

Ques. 103. How should the receiving set be adjusted to a certain transmitting station during heavy static?

Ans. To receive in heavy static, extremely loose coupling is required. It is necessary when using loose coupling to tune very carefully, as a small variation from the proper posi-

tion will tune most signals out. When using loose coupling on an inductively coupled set, it is necessary to increase secondary capacitance as the coupling is increased and to decrease slightly the secondary inductance.

Ques. 104. What is the advantage of a variable condenser across the secondary of a receiving transformer?

Ans. The secondary variable condenser permits accurate tuning of the secondary circuit to the antenna circuit.

Ques. 105. Explain two methods of receiving undamped signals.

Ans. (a) Heterodyne, (b) Ticker.

The heterodyne method is one in which a local current of radio frequency is superimposed upon an incoming frequency of electromagnetic waves, resulting in a frequency equal to the difference between the incoming and the superimposed frequencies. For example, if the incoming radio frequency is 100,000 cycles per second, the local frequency 99,000 cycles, then the resultant note will have a frequency of 1000 pulses per second.

The ticker method of undamped wave reception is explained under question No. 94.

Ques. 106. Give a diagram of an audibility meter.

Ans. A diagram of an audibility meter manufactured by the General Radio Company is given below, figure 40.

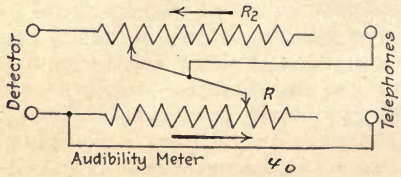


Fig. 40. Audibility Meter

Part VII

VACUUM TUBES

Ques. 107. What is the usual plate voltage employed to function an audion detector?

Ans. The usual plate voltage is 22.5 volts and is usually supplied by a standard 22½ volt dry battery or a storage battery.

Ques. 108. What means are usually provided for supplying filament current for the successful operation of a vacuum tube detector?

Ans. The filament current is supplied by storage batteries in most cases.

Ques. 109. What is the difference between a Fleming valve and an audion detector?

Ans. The Fleming valve has two elements, a plate and a filament. The audion has three elements, a plate, a grid, and a filament.

Ques. 110. How may the sensitivity of a valve be increased?

Ans. The sensitivity of a vacuum tube depends upon:

a. Correct filament brilliancy.
b. Correct plate voltage.
c. Degree of vacuum.

The filament current may be adjusted by the A battery rheostat while signals are received and left in the position of maximum signal. It frequently happens that the B battery supplying the plate voltage drops in voltage very quickly after reaching a certain point of discharge. Therefore, careful attention must be paid to the state of charge of this

battery. After the vacuum tube set has been operated for some little time, charging the B battery invariably increases its sensitiveness. The degree of vacuum has a marked effect upon the sensitivity of a vacuum tube. If after long use it is suspected that the degree of vacuum is becoming less, the tube may be held over a candle flame until the bulb becomes warm. This will in some cases partly restore the vacuum and incidently increase the sensitivity of the bulb.

Ques. 111. Describe an audion detector. What is its basic principle?

Ans. An audion detector consists of an exhausted glass bulb containing three elements, filament, plate and grid. The basic principle of its operation is that when a metal is heated above red heat a violent electronic emission occurs. In the audion these electrons are given off by the filament and strike the plate. The intensity of electron flow from filament to plate is controlled by the grid. The stream of electrons explained above will act as a conducting path for an electric current more favorably in one direction under certain adjustments. Therefore, it can be used as a rectifier and this is its function when used as a detector.

Ques. 112. What instrument is used to regulate the current to the filament and what is the purpose for such regulation?

Ans. The filament current in a vacuum tube is regulated by a low resistance rheostat. The reason for such regulation is that the sensitiveness of the tube is increased by careful regulation of the filament current. The filament current rheostat also prevents a recuperated battery from burning out the filament when it is first lighted.

Ques. 113. What is the effect of reversed polarity on the plate and filament circuit of a vacuum tube?

Ans. If the plate connections are of reversed polarity no signals will be heard. If the filament circuit is reversed signals may be heard although of decreased intensity.

Part VIII

LAWS AND TRAFFIC REGULATIONS

Ques. 114. What is the U. S. distance requirement for auxiliary equipment?

Ans. The auxiliary equipment must be able to send one hundred miles for a period of four hours at the least.

Ques. 115. Give the complete procedure in calling a station.

Ans. Before calling a station the operator must first make sure that the station he wishes to call is not busy; secondly, that he will interfere with no authorized traffic already going on. If the transmission may be made proceed as follows:

Example:

Ship KQP calls NAH

—.—.—

NAH NAH NAH

—.. .

KQP KQP KQP

Ques. 116. Give the complete procedure in answering a call.

Ans. Example:

NAH having been called answers

KQP KQP KQP

—.. .

NAH

—.—

Ques. 117. Has the master of the vessel the right to censor all messages received and transmitted by the radio station?

Ans. Yes, the master of a ship is in supreme control of all messages handled by the radio station.

Ques. 118. Explain fully the cable count system.

Ans. The cable count system of counting the check is used for radiograms. This system provides that all words in the address, text, and signature must be counted and charged for. In this system messages are divided into three classes, viz.:

(a) Plain language.
(b) Code language.
(c) Cipher language.

Plain Language messages must be written entirely in plain language. Words are counted on the basis of fifteen characters to the word. Any fractional part of fifteen characters is also counted as one word. Numbers up to five in a group would be counted as one word, over five as two words.

Examples:

Gymnasium	1 word	7583	1 word
Intellectualization	2 words	37463	1 word
Unconstitutional	2 words	987641	2 words
Constantinople	1 word		

Code Language is made up of pronounceable words of no direct meaning not to exceed ten characters in length. If a code word exceeds ten characters in length it is counted at the cipher rate (5 letters to the word) and this is noted in the check. Non-pronounceable code words are counted at the cipher rate. Words in which the meaning has been concealed by reversing the order of the letters or syllables will not be accepted as code words.

Examples:

BEYINXJEHI	1 word
X-ray	2 words
XQNOW	Not accepted—counted as cipher.

Cipher Language is counted at the rate of five letters to the word and may be made up of any combination of letters or figures.

Examples:

QPWNY	1 word
QPXNWY	2 words
A5C	3 words

When a message is written in mixed language a careful check-up under the following rules must be made.

Code and Plain Language. Maximum length of word chargeable is ten characters.

Plain Language and Cipher. The plain language is charged at the rate of one word for every fifteen characters or fraction thereof, and the groups in the passages in cipher language at the rate of one word for every five characters or fraction thereof.

Plain Language, Code Language and Cipher Language. The words in plain language and code language are charged as code language and the words in cipher are charged as cipher. The word street, road, park, or square is always counted as one word aside from its designator in the address. Hyphenated or compound words are counted as so many separate words depending on the number of parts.

Names of places, such as New York, New London, or Frankfort Maine, are counted as one word in the address and two words in the text.

If New York is written Newyork or New London is written Newlondon and like examples, they are counted as one word in the text and so charged for. They should be written as two separate words in the address but as the names of all cities count as one word in the address they are charged for as one word.

Ques. 119. Give and explain twelve International abbreviations.

Ans. Below is the International List of Abbreviations which are self-explanatory. Any twelve signals may be chosen. If the three letter signal is sent followed by a ques-

tion mark, it refers to the first column of explanation. If the signal is sent alone it refers to the second column of explanation. See list figure 41.

Ques. 120. What are the penalties for violation of the act of August 13, 1912?

Ans. For violation of any of the regulations of this act, the owner of the apparatus shall be liable to a penalty of one hundred dollars, which may be remitted or reduced by the Secretary of Commerce. For repeated violations the license may be revoked.

An operator may be subject to a penalty of twenty-five dollars, which may be reduced or remitted by the Secretary of Commerce. For repeated violations the license shall be suspended or revoked.

Ques. 121. State the law regarding the testing of a transmitter.

Ans. The law provides for testing as follows: Stations desiring to conduct tests should communicate with radio inspector by letter or telephone, stating the probable length of time that will be required. Stations conducting such tests or temporary experiments should "listen in," to determine that no interference is being caused, and during the tests should "listen in" frequently for the interference signal, "Q.R.M." Stations conducting tests should transmit their official call signal frequently. Attention is invited to the act of August 13, 1912, section 5:

"That every license granted under the provisions of this act for the operation or use of apparatus for radio communication shall prescribe that the operator thereof shall not willfully or maliciously interfere with any other radio communication. Such interference shall be deemed a misdemeanor, and upon a conviction thereof the owner or operator, or both, shall be punishable by a fine not to exceed five hundred dollars or imprisonment for not to exceed one year, or both."

DEPARTMENT OF COMMERCE
BUREAU OF NAVIGATION
RADIO SERVICE

INTERNATIONAL RADIOTELEGRAPHIC CONVENTION

LIST OF ABBREVIATIONS TO BE USED IN RADIO COMMUNICATION

ABBREVIATION	QUESTION	ANSWER OR NOTICE
PRB	Do you wish to communicate by means of the International Signal Code?	I wish to communicate by means of the International Signal Code.
QRA	What ship or coast station is that?.....	This is.....
QRB	What is your distance?.....	My distance is.....
QRC	What is your true bearing?.....	My true bearing is.....degrees.
QRD	Where are you bound for?.....	I am bound for.....
QRF	Where are you bound from?.....	I am bound from.....
QRG	What line do you belong to?.....	I belong to the.....Line.
QRH	What is your wave length in meters?.....	My wave length is.....meters.
QRJ	How many words have you to send?.....	I have.....words to send.
QRK	How do you receive me?.....	I am receiving well.
QRL	Are you receiving badly? Shall I send 20?..	I am receiving badly. Please send 20.
	. . — . . — for adjustment?.....	. . — . . — for adjustment.
QRM	Are you being interfered with?.....	I am being interfered with.
QRN	Are the atmospherics strong?.....	Atmospherics are very strong.
QRO	Shall I increase power?.....	Increase power.
QRP	Shall I decrease power?.....	Decrease power.
QRQ	Shall I send faster?.....	Send faster.
QRS	Shall I send slower?.....	Send slower.
QRT	Shall I stop sending?.....	Stop sending.
QRU	Have you anything for me?.....	I have nothing for you.
QRV	Are you ready?.....	I am ready. All right now.
QRW	Are you busy?.....	I am busy (or: I am busy with.....). Please do not interfere.
QRX	Shall I stand by?.....	Stand by. I will call you when required.
QRY	When will be my turn?.....	Your turn will be No. .....
QRZ	Are my signals weak?.....	Your signals are weak.
QSA	Are my signals strong?.....	Your signals are strong.
QSB	Is my tone bad?.....	The tone is bad.
QSC	Is my spark bad?.....	The spark is bad.
QSD	Is my spacing bad?.....	Your spacing is bad.
QSF	What is your time?.....	My time is.....
	Is transmission to be in alternate order or in series?	Transmission will be in alternate order.
QSG	.....	Transmission will be in series of 5 messages.
QSH	.....	Transmission will be in series of 10 messages.
QSJ	What rate shall I collect for.....?	Collect.....
QSK	Is the last radiogram canceled.....	The last radiogram is canceled.
QSL	Did you get my receipt?.....	Please acknowledge.
QSM	What is your true course?.....	My true course is.....degrees.
QSN	Are you in communication with land?.....	I am not in communication with land.
QSO	Are you in communication with any ship or station (or: with.....)?	I am in communication with..... (through.....).
QSP	Shall I inform.....what you are calling him?	Inform.....that I am calling him.
QSQ	Is.....calling me?.....	You are being called by.....
QSR	Will you forward the radiogram?.....	I will forward the radiogram.
QST	Have you received the general call?.....	General call to all stations.
QSU	Please call me when you have finished (or: at.....o'clock)?	Will call when I have finished.
*QSV	Is public correspondence being handled?....	Public correspondence is being handled. Please do not interfere.
QSW	Shall I increase my spark frequency?.....	Increase your spark frequency.
QSX	Shall I decrease my spark frequency?.....	Decrease your spark frequency.
QSY	Shall I send on a wave length of..... meters?	Let us change to the wave length of..... meters.
QSZ	.....	Send each word twice. I have difficulty in receiving you.
QTA	.....	Repeat the last radiogram.
QTE	What is my true bearing?.....	Your true bearing is ..... degrees from .....
QTF	What is my position?.....	Your position is .... latitude .... longitude.

*Public correspondence is any radio work, official or private, handled on commercial wave lengths.

When an abbreviation is followed by a mark of interrogation, it refers to the question indicated for that abbreviation.

11—8869

Fig. 41. International Abbreviations

The Department holds that interference caused by tests of the character described above is "willful" when no "listening in" precautions are taken and the call signal of the station sending is not repeated at intervals.

Under certain conditions local radio inspectors frame regulations to suit the needs of a particular district. In the New York vicinity, for example, where the number of testers is very great, a separate call signal is assigned to each authorized tester and testing allowed only during certain periods of the hour.

Ques. 122. Set up a radiogram with a twelve word check.

Ans. Example:

To: John Hopkins,
12 Henry Avenue,
Baltimore (Md.)
Will arrive early Sunday morning.
James.

NOTE: The name of the state when enclosed in parenthesis is not counted in the check or charged for.

The abbreviations listed below have been put into effect since the original list on page 67 was compiled.

Abbreviation	Question	Answer or Notice
QTB	Are you in accord with my check? Please repeat first letter or figure of each counted word.	I am not in accord with you in your statement of the number of words. I repeat the first letter of each word and the first figure of each number.
QTC	Have you anything to transmit?	I have something to transmit, or I have one or several radiograms for.....

Part IX

INFORMATION REGARDING GOVERNMENT RADIO LICENSE EXAMINATION

After June 30, 1921, licenses to radio operators will be issued according to the following regulations. These regulations affect only licenses of the commercial operator. Licenses will be ranked as to class and grade. There will be a first class and a second class. The class certifies to an operator's proficiency as a radio man. In addition to the class the licenses will also be graded as first, second and third grade.

The theoretical passing mark will be 75 per cent for first class and 65 per cent for second class. As far as class is concerned any person is eligible for either the first or second class.

The grade of a license shows the service an operator has had. No service is required for the third grade, six months satisfactory service is required for second grade. Twelve months as a second grade operator must be had in order to be eligible for a first grade license.

The code requirements are twelve words per minute for any second class license, twenty words per minute for first class, second grade, and twenty-five words per minute for first class, first grade.

The extra first class license is issued by the Department of Commerce to exceptional operators of good standing. The requirements in code are thirty words per minute Continental Morse and twenty-five words per minute American Morse (five letters to the word). Satisfactory service for eighteen months during the term of the applicant's unexpired license is required. A theoretical mark of 80 or better must be attained.

Credit for the examination is given on the following basis:

	Points, maximum value.
(a) Experience	20
(b) Diagram of receiving and transmitting apparatus (fig. 43)	10
(c) Knowledge of transmitting apparatus	20
(d) Knowledge of receiving apparatus	20
(e) Knowledge of operation and care of storage batteries	10
(f) Knowledge of motors and generators	10
(g) Knowledge of Radio Regulations	10

PLACES OF EXAMINATION

Examination for radio operator's license may be taken by making application to the Radio Inspector at any of the following places:

Boston, Mass.
New York, N. Y.
Philadelphia, Pa.
Norfolk, Va.
Charleston, S. C.
New Orleans, La.
Mare Island, Calif.
Puget Sound, Wash.
San Juan, P. R.
Colon, Canal Zone.
Honolulu, Hawaii.
Key West, Fla.
Fort Omaha, Nebr.
Fort Wood, N. Y.
Fortress Monroe, Va.
Fort St. Michael, Alaska.
Fort Valdez, Alaska.
Bureau of Navigation, Dept. of Commerce, Washington, D. C.

Part X

ADDITIONAL QUESTIONS

Are you well versed in practical radio? If you are, here are sixty questions you should be able to answer. All of these questions are not asked in license examinations and are included here for test purposes only.

1. Explain the construction of a quenched spark gap; what are its advantages and how does it function in a transmitting set?

2. Describe the relative advantages and disadvantages of damped and undamped waves.

3. An antenna 200 feet long and 100 feet high inverted L is erected on a dry sandy beach (soil) near seashore. Describe a suitable ground for a 5 K.W. transmitter.

4. Why is a closed circuit not a good radiator of electric waves?

5. Describe the Alexanderson H.F. alternator.

6. Diagram of Lowenstein wavechanger.

7. Explain the theory and action of a circuit breaker and how to adjust it.

8. Tell for what uses series, shunt, and compound motors are best adapted. Give reasons.

9. What are interpoles used for on D.C. machines?

10. Describe the types of grounds used with sets operating on sandy or dry ground and state the advantages or disadvantages of each.

11. Describe the construction of an induction coil or transformer. Give sketch.

12. Where are variable condensers used to advantage? Give diagram.

13. Describe two types of variable condensers.

14. What class of radiograms have precedence over all others?

15. Why are condensers sometimes submerged in oil?

16. How do you proceed to adjust a crystal detector to maximum sensitiveness?

17. Explain the difference between broad and sharp tuning and advantages of each.

18. What is meant by normal rate of charge of a storage battery?

19. What are the causes of the breakdown of the insulation of an antenna?

20. How would you test for an open circuit in the primary or secondary of your induction coil or transformer?

21. What is advantage of cooling the spark gap by air blast or other means?

22. What is the difference between A.C. and interrupted direct current?

23. What may be the trouble if H.W.A. does not register?

24. What is the first thing to do after receiving a message?

25. Describe at least one method of determining the following antenna measurements:

(a) Fundamental wavelength,
(b) Capacity,
(c) Inductance,
(d) Resistance.

26. In case two or three leyden jars of the main transmitter were broken and having no spare jars, how would you adjust your transmitter to the original wavelengths? What effects would this adjustment have on the coupling?

27. Describe an improved type receiver for the reception of undamped waves. Make a sketch of the circuits used in the receiver.

28. Draw an elementary diagram of the following:

(a) A magnetic coupled receiver connected to a crystal detector for receiving damped waves.

(b) A static or capacity coupled receiver connected to an ultra audion for receiving undamped waves.

In the latter show a tickler coil connected in the circuit and describe the various parts that go to make up the circuit and how the ultra audion enables you to receive undamped waves.

29. What is the function of a starting box for a motor and how is it constructed? If one of the steps of the resistance burned out, how would you temporarily repair the fault? Describe the action of no voltage and overload devices. What material should be used for cleaning a commutator?

30. If your starting rheostat burned out, what material ordinarily found on shipboard could be used to repair it temporarily, to replace it, and how would you use this temporary apparatus?

31. How are dynamos classified in respect to their field excitation?

32. Explain the difference between a Motor Generator and a Dynamotor.

33. State in detail all the factors that determine the range of a radio station.

34. Describe an arc transmitter, giving a schematic diagram of the circuits. How does the radiation emitted by an undamped wave transmitter differ from that emitted by a spark system? Given a certain transmitting equipment and a certain antenna at what wavelengths will the maximum

radiation be obtained? How will the radiation vary at different wavelengths?

36. Name and describe the most common form of detector for undamped waves, what are its advantages and disadvantages?

37. How may a pure note be obtained in the reception of undamped waves? Describe the construction and operation of one device for this purpose.

38. What is meant by "multiple discharges" in a radio transmitter? What advantages are found in this, and under what conditions?

39. What is the difference between trains of waves emitted by the transmitter and the note heard at the receiver?

40. What is the function of an earth connection? Describe an efficient ground system.

41. Describe the operation of tuning a receiver for the reception of weak signals through interference. Do not make general statements, but describe in sequence and in minute detail every step of the operation from start to finish, in order to obtain the best results.

42. What special methods or devices are effective in receiving through static, except careful tuning?

43. If the ship's masts are destroyed, how could you arrange to send and receive radio signals?

44. Why is special care required in making joints in antenna wire? What forms of coupling are used in radio transmitters? What are the advantages and disadvantages of each? How can the wavelength of a distant transmitting station be determined at the receiving station?

45. What simple test can you apply to see whether your antenna is grounded somewhere outside the building (station).

46. How may the amount of power used in sending a radiogram be changed?

47. What is meant by the following: (a) A cumulatively compound wound motor; (b) a differential compound wound motor. Which type is used for operating radio A.C. generators and why?

48. An alternator has twelve pole pieces; at what speed must it be run to generate frequency of 150 cycles per second?

49. Describe the action of an induction motor.

50. How does a single phase motor differ from a three phase motor?

51. A transformer is supplied with A.C. at 200 volts and a frequency of 60 cycles. If it has 500 times as many turns in the secondary as in the primary what voltage will be induced in the secondary, and how many times will the voltage rise per second to a maximum?

52. What are the standard sizes of antenna wire in commercial service? What is the tensile strength?

53. What kind of insulators are used for spreading the antenna?

54. In building a flat top antenna how far apart would you spread the wires?

55. Is it good practice to solder the connection in an antenna?

56. How would you count a radiogram composed of code, plain language and cipher? Would you accept a paid service message destined to a ship at sea? If so, how would it differ from an ordinary commercial radiogram to the same ship?

57. Should the number of words shown in the check of a radiogram differ from the number of words in the message; how would you handle same if the ship had passed out of radio range? How long should you hold an undelivered radio-

gram of a commercial nature (destined to a ship) at a shore station before filing it?

58. What are the SVC messages? Give the form of a SVC message.

59. Give all the requirements and limitations concerning relaying for both shore and ship stations. In the case of a message originating on shipboard, what must be shown in the record of such a message? In the case of a message received on shipboard, what must be shown on the record of such message?

60. Explain one theory of rectification by crystal detector.

ELECTRICAL DEFINITIONS

Volt: (1) Is the E.M.F. induced in a circuit when the number of lines of force linked with it change at the rate of 108 per second.

(2) The E.M.F. required to force one ampere through a R of one ohm.

Ampere: (1) The amount of current that when passed through a solution of silver nitrate will deposit .001118 grams of silver per second.

(2) The amount of current flowing in a circuit having a resistance of one ohm at a pressure of one volt.

Ohm: (1) The resistance offered to an unvarying current by a column of mercury at temperature of melting ice 14.4521 grams in mass and 106.3 centimeters long.

(2) The R of a circuit that will pass one ampere at a pressure of one volt.

Coulomb: The coulomb is the unit of quantity. It is the amount of electricity passed by one ampere in one second.

Joule: The joule is the unit of quantity. It is the energy expended by one ampere through one ohm.

Farad: The farad is the unit of quantity. It is the capacity of a condenser charged to one volt by one coulomb of electricity.

Watt: The watt is the unit of power. It is the work done by one joule per second.

Henry: The henry is the unit of inductance. It is the induction in a circuit when the E.M.F. equals one volt while the current changes at the rate of one ampere per second.

Conductance: Reciprocal of R.

Inductance: Property of a circuit that tends to prevent any change in the strength of the current passing through it.

Reactance: Reactance is due to counter E.M.F. of self-inductance and is expressed in equivalent ohms.

Impedance: This is the combined opposition of reactance and resistance to a current in any circuit.

Potential: When two condensers are charged with electricity and they are capable of giving off a spark discharge of certain defined length. The one giving the longest spark discharge in linear length is said to have been charged to a higher potential.

Current: The term current means the quantity of electricity which passes in a unit of time, and is expressed in amperes. The current in a circuit in inversely proportional to the resistance in the circuit.

Resistance: The resistance of a circuit is the property of the conductor to oppose the flow of the current. The unit of resistance is the ohm and is the resistance of a column of mercury 14.4521 grams in mass and 106.3 centimeters long at the temperature of melting ice. It is the resistance in a circuit when the E.M.F. is one volt and the current one ampere.

Capacitance: The property of a condenser by which energy may be stored up in electro-static form. The unit of capacitance is the farad and is the capacity of a condenser when it is charged to a potential of one volt by one coulomb of electricity.

Inductance: The property of a circuit that tends to oppose any change in strength or direction of E.M.F. in an alternating current circuit. The unit of inductance is the Henry and is the inductance in a circuit where the applied E.M.F. is one volt and is changing at the rate of one ampere per second.

Frequency: The number of times that an alternating current changes direction when expressed in figures; it is the number of changes or cycles per second of time.

Phase: As applied to alternating current denotes the angle turned through by the generating element reckoned from a given instant. Phase is usually measured in degrees from the initial point of zero generation.

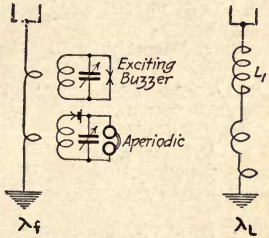


Fig. 42. Measuring Induction and Capacitance of Antenna

Measurement of Inductance and Capacity of Antenna. The fundamental λ_f should be carefully measured by use of a periodic circuit, (fig 42) care being taken that fundamental λ of aperiodic circuit is not close to λ_f. A known inductance L_1 is then inserted and loaded fundamental, λ_L measured. Then

$$\lambda_f = K\sqrt{LC}$$

$$\lambda_L = K\sqrt{(L+L_1)C}$$

$$= L = \frac{\lambda^2_f L_1}{\lambda^2_L - \lambda^2_f}$$

C may be found by substitution

$$C = \frac{\lambda^2_1 - \lambda^2_2}{\lambda^2_1} \cdot C$$

BIBLIOGRAPHY

Text Books Suitable for Radio Students.

1. Robison, "Manual of Radio Telegraphy and Telephony."
2. Stone, "Elements of Radio Telegraphy."
3. Fleming, "Elementary Manual of Radio Telegraphy and Radio Telephony."
4. Bucher, "Practical Wireless Telegraphy."
5. Hayward, "How to Become a Radio Operator."
6. U. S. Signal Corps, "Radio."
7. Stanley, "Wireless Telegraphy."
8. Goldsmith, "Radio Telephony."
9. Bangay, "The Elementary Principles of Wireless Telegraphy," volume I and II.
10. Lauer and Brown, "Principles of Radio Engineering."

ARC TRANSMITTERS

1. Manual for Radio Operators
   Published by Federal Telegraph Company
2. Robinson's Manual for Naval Electricians
   U. S. Naval Institute, Annapolis, Md.
3. I. R. E. Proceedings; Volume 5 No. 4, P. O. Pedersen, "On the Poulsen Arc and its Theory"; Volume 7, No. 5, L. F. Fuller "The Design of Poulsen Arc Converter for Radio Telegraphy"; Volume 9, No. 3, P. O. Pedersen "On the Poulsen Arc in Coupled Circuits."
4. Bucher, "Practical Wireless Telegraphy."

STORAGE BATTERIES

1. Croft "Practical Electricity."
2. U. S. Signal Corps "Radio."
3. Pamphlets published by the Electric Storage Battery Company, Philadelphia, Pa.
4. Pamphlets published by the Edison Storage Battery Company, Orange, New Jersey.
5. Bucher, "Practical Wireless Telegraphy."

GENERAL ELECTRICITY

1. Croft, "Practical Electricity."
2. Swoope, "Lessons in Practical Electricity."
3. Timbie, "Essentials of Electricity."

VACUUM TUBES

1. Lauer and Brown, "Principles of Radio Engineering."
2. Bucher, "Vacuum Tubes."
3. I. R. E. Proceedings; Volume 2, No. 1, "The Audion Detector and Amplifier"; Volume 5, No. 2, "A Study of Hetrodyne Amplification by the Electron Relay"; Volume 5, No. 6, "The Manufacture of Vacuum Tube Detectors."
4. Lodge, "Electrons."

RADIO LAWS AND REGULATIONS

1. U. S. Radio Regulations
   Superintendent of Documents, Government Printing Office, Washington, D. C.
2. Commercial Traffic Regulation
   Superintendent of Documents, Government Printing Office, Washington, D. C.

APPENDIX I

The Chemistry of the Edison Storage Battery. The fundamental principle of the Edison Storage Battery is the oxidation and reduction of metals in an electrolyte which neither combines with nor dissolves either the metals or their oxides. Also, an electrolyte which, notwithstanding its decomposition by the action of the battery, is immediately re-formed in equal quantity, and is, therefore, a practically constant element without change of density or conductivity over long periods of time. Therefore, only a small quantity of such electrolyte is necessary, permitting a very close proximity of the plates. Furthermore, it is unnecessary to take hydrometer readings until about three hundred cycles of charge and discharge have been made; this is simply to determine when it is necessary to empty out the old solution and put in new. The active materials of the electrodes being insoluble in the electrolyte, no chemical deterioration takes place therefrom.

The chemical reactions in charging the Edison Storage Battery are, (1) the oxidation from a lower to a higher oxide of nickel in the positive plate, and (2) the reduction from ferrous oxide to metallic iron in the negative plate. The oxidation and reduction are performed by the oxygen and hydrogen set free at the respective poles by the electrolytic decomposition of water during the charge. The charging of the positive plate is, therefore, simply a process of increasing the proportion of oxygen to nickel. The proportions of nickel to oxygen in definite oxides of nickel are as follows:

	Atomic Proportions		By Weight	
	Ni	O	Ni	O
Ni O	1	1	1	.273
Ni_3O_4	1	1.33	1	.364
Ni_2O_3	1	1.5	1	.409
$Ni O_2$	1	2	1	.545

The relative amounts of oxygen necessary to oxidize nickelous oxide, or NiO, which is the oxide corresponding to the green nickel hydrate used in making the battery, to the various oxides are given in the three reactions:

(1) $6\ Ni O + 2O = 2\ Ni_3O_4$
(2) $6\ Ni O + 3O = 3\ Ni_2O_3$
(3) $6\ Ni O + 6O = 6\ Ni O_2$

The NiO_2 is capable of reacting with NiO according to the reaction $NiO_2 + NiO = Ni_2O_3$. Ni_3O_4 is considered as a combination of $NiO + Ni_2O_3 = Ni_3O_4$.

From a chemical standpoint a charged condition of the cell would, therefore, be represented in the positive plate by an atomic ratio of nickel to oxygen of at least 1:1.5 (or Ni_2O_3), depending on the charge. A discharged condition would be represented by a ratio of 1:1.33 (Ni_3O_4) or lower, depending on the discharge.

The discharge of the cell is simply the reversal of the above reactions, the hydrogen reducing the higher oxides of nickel to lower oxides and the oxygen oxidizing the iron to ferrous oxide.

APPENDIX II.

THE CARE OF BALL BEARINGS*

LUBRICATION. As these machines cannot always be placed on ship-board with the shaft fore and aft, there may be times when they will be subjected to severe rolling and it is, therefore, desirable in general to use a medium grade of grease similar to No. 3 Keystone grease which is made by the Keystone Lubricating Company of Philadelphia, Pa. A slightly lighter grease could be used in cold weather or where there would not be much rolling. Any similar good grade of grease would be satisfactory but it must be absolutely neutral or test free from acid or alkali.

The other important requirement is that the grease must contain no fibrous material and must withstand a temperature of 100 degrees C or higher without any material change in its consistency when cold. Some greases, upon being heated, separate into a thin oil and a relatively viscous soapy material. This kind of a grease should not be used unless absolutely necessary. If the bearings are filled full of grease it will be found that a portion of this will, after running for a time, work out of the ends of the bearings, leaving, however, sufficient to properly lubricate same. After operating for a month or so it is desirable to thoroughly flush out the bearings with gasoline or kerosene oil and fill with a good grease. After this, if the bearings are kept free from all dirt, grit, etc., they should not need cleaning and refilling with grease more often than every six months.

*From directions published by Crocker-Wheeler Co.

CLEANLINESS. This is an extremely important matter with ball bearings and, therefore, all foreign material except the grease must be carefully excluded. Care must be taken that no dirt or grit of any kind is carried into the bearing with the new grease, or otherwise, when, for any reason, the bearing caps are removed.

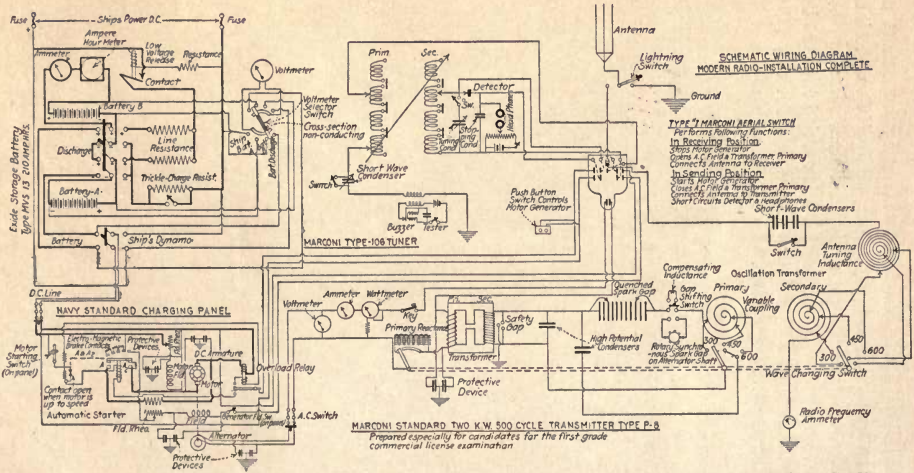


Fig. 43. Diagram of Receiving and Transmitting Apparatus, Complete. (Counts as Ten Points Credit on Government Examination for Radio Operators' License.)